(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 May 2011 (12.05.2011)

PCT

(10) International Publication Number
WO 2011/056265 A1

(51) International Patent Classification:
B60W 20/00 (2006.01)

(21) International Application Number:
PCT/US2010/039778

(22) International Filing Date:
24 June 2010 (24.06.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PCT/US2009/063468
6 November 2009 (06.11.2009) US
PCT/US2009/063470
6 November 2009 (06.11.2009) US
PCT/US2009/063561
6 November 2009 (06.11.2009) US

(71) Applicant *(for all designated States except US)*: **INTERNATIONAL TRUCK INTELLECTUAL PROPERTY COMPANY, LLC** [US/US]; 4201 Winfield Road, Legal Dept., Warrenville, Illinois 60555 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **BISSONTZ, Jay** [US/US]; 829 Woodland Springs Place, Fort Wayne, Indiana 46825 (US).

(74) Agents: **BACH, Mark** et al.; 4201 Winfield Road, Warrenville, Illinois 60555 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

[Continued on next page]

(54) **Title**: CONTROL SYSTEM FOR EQUIPMENT ON A VEHICLE WITH A HYBRIDELECTRIC POWERTRAIN

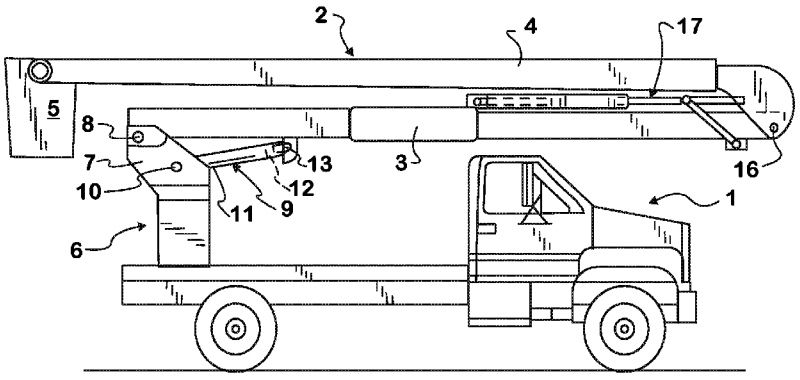


FIG. 1

(57) **Abstract**: A vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain. A body computer connects to the controller area network to receive chassis input signals. A controller area network has an electronic control module, a transmission control module, and a hybrid control module. The electronic control module electrically connects to the transmission control module and the hybrid control module. A data link based remote power module is installed on the vehicle for generating body demand signals for initiating operation of the vehicle hybrid electric powertrain for a power take off operation. A plurality of PTO request switches are electrically connected to the controller area network. The body computer is programmable to accept a signal from at least one of the PTO request switches to change an operating state of the power take off operation.

WO 2011/056265 A1

— *with amended claims (Art. 19(1))*

CONTROL SYSTEM FOR EQUIPMENT ON A VEHICLE WITH A HYBRID-ELECTRIC POWERTRAIN

DESCRIPTION

RELATED APPLICATIONS

[0001] The present application claims priority to International Application Number PCT/US09/63468 filed on November 6, 2009, International Application Number PCT/US09/63470 filed on November 6, 2009, and International Application Number PCT/US09/63561 filed on November 6, 2009. These applications are incorporated herein in their entireties by this reference

TECHNICAL FIELD

[0002] The present disclosure relates to a hydraulic load control system for power take off ("PTO") equipment on a vehicle with a hybrid-electric powertrain, and more particularly to a system and method for transitioning between internal combustion engine powered operation of the PTO and hybrid-electric powertrain powered operation of the PTO that supplies power for the hydraulic load.

BACKGROUND

[0003] Many vehicles now utilize hybrid-electric powertrains in order to increase the efficiency of the vehicle. A hybrid-electric powertrain typically involves an internal combustion engine that operates a generator that produces electrical power that may be used to drive electric motors used to move the vehicle. The electric motors may be used to provide power to wheels of the vehicle to move the vehicle, or the electric motors may be used to supplement power provided to the wheels by the internal combustion engine and a transmission. In certain operational situations, the electric motors may supply all of the power to the wheels, such as under low speed operations. In addition to providing power to move the vehicle, the hybrid-electric powertrain may be used to power a PTO of the vehicle, sometimes also referred to as an electric PTO or EPTO when powered by a hybrid-electric powertrain, that in turn powers PTO driven accessories.

[0004] In some vehicles, such as utility trucks, for example, a PTO may be used to drive a hydraulic pump for an on-board vehicle hydraulic system. In some configurations, a PTO

driven accessory may be powered while the vehicle is moving. In other configurations, a PTO driven accessory may be powered while the vehicle is stationary and the vehicle is being powered by the internal combustion engine. Still others may be driven while the vehicle is either stationary or traveling. Control arrangements are provided for the operator for any type of PTO configuration.

[0005] In some PTO applications the vehicle's particular internal combustion engine may be of a capacity that makes it inefficient as a source of motive power for the PTO application due to the relatively low power demands, or intermittent operation, of the PTO application. Under such circumstances the hybrid-electric powertrain may power the PTO, that is, use of the electric motor and generator instead of the IC engine to support mechanical PTO, may be employed. Where power demands are low, the electric motor and generator will typically exhibit relatively low parasitic losses compared to an internal combustion engine. Where power demand is intermittent, but a quick response is provided, the electric motor and generator provides such availability without incurring the idling losses of an internal combustion engine.

[0006] Conventionally, once a hybrid electric vehicle equipped for EPTO enters the EPTO operational mode, the electric motor and generator remains unpowered until an active input or power demand signal is provided. Typically, the power demand signal results from an operator input received through a body mounted switch which is part of data link module. Such a module could be the remote power module described in United States Patent 6,272,402 to Kelwaski, the entire disclosure of which is incorporated herein by this reference. The switch passes the power demand signal over a data bus such as a Controller Area Network (CAN) now commonly used to integrate vehicle control functions.

[0007] A power demand signal for operation of the traction motor is only one of the possible inputs that could occur and which could be received by a traction motor controller connected to the controller area network of the vehicle. Due to the type, number and complexities of the possible inputs that can be supplied from a data link module added by a truck equipment manufacturer (TEM), as well as from other sources, issues may arise regarding adequate control of the electric motor and generator, particularly during the initial phases of a product's introduction, or during field maintenance, especially if the vehicle has been subject to operator modification or has been damaged. As a result the traction motor may not operate as expected. In introducing a product, a TEM can find itself in a situation where the data link module cannot provide accurate power demand requests for electric

motor and generator operation for EPTO operation due to programming problems, interaction with other vehicle programming, or other architectural problems.

[0008] A hybrid-electric powertrain may solely power the PTO of the vehicle when the PTO is operating a PTO driven accessory adapted to only be utilized by a stopped vehicle, such as lift attachment, or a digging attachment. In some situations, the hybrid-electric powertrain is not capable of providing sufficient power to the PTO, and thus, the PTO needs to be powered by the internal combustion engine. In other situations, batteries of the hybrid-electric powertrain may need to be recharged. In both of these situations, if the PTO is being powered by the hybrid-electric powertrain, the PTO must be stopped, such that the internal combustion engine may be started to deliver power to the PTO, or to recharge batteries of the hybrid-electric powertrain. Therefore, a need exists for a system and method that is capable of shutting down a PTO that is being driven by a hybrid-electric powertrain, such that an internal combustion engine may be started to power the PTO, or to recharge batteries of the hybrid-electric powertrain.

SUMMARY

[0009] According to one embodiment, a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain comprises a controller are network, a data link, and programming. The controller area network and body computer are connected to receive a plurality of chassis input signals. The data link based remote power module is installed on the vehicle and generates body demand signals for initiating operation of the vehicle hybrid electric powertrain for a power take off operation. The programming is for execution by the body computer in response to selected chassis input signals for generating control signals for the hybrid electric powertrain for the power take off operation.

[0010] According to another embodiment, a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain, comprises means responsive to a plurality of chassis input signals for generating a chassis demand signal for initiating operation of the hybrid electric powertrain to support power take off operation. The vehicle additionally comprises means responsive to operator inputs and installed on the vehicle for generating body demand signals for initiating operation of the hybrid electric powertrain to support power take off operation.

[0011] According to a further embodiment, a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain comprises a controller area network, a body computer, a data link based remote power module, and a

plurality of PTO request switches. The body computer is connected to the controller area network to receive a plurality of chassis input signals. The controller area network additionally has an electronic control module, a transmission control module, and a hybrid control module. The electronic control module is electrically connected to the transmission control module and the hybrid control module. The data link based remote power module is installed on the vehicle for generating body demand signals for initiating operation of the vehicle hybrid electric powertrain for a power take off operation. The PTO request switches are electrically connected to the controller area network. The body computer is programmable to accept a signal from at least one of the PTO request switches to change an operating state of the power take off operation.

[0012] According to another embodiment, a control system for a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain, comprises a controller area network and a plurality of PTO request switches. The controller area network has an electronic control module, a body computer, and a remote power module. The plurality of PTO request switches are electronically connected to the controller area network. The body computer is programmable to receive a signal from at least one of the PTO request switch to change an operating state of a power take off operation.

[0013] According to one process, a method of engaging a power take off of a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain is provided. A controller area network is programmed to accept a PTO request signal from at least one of a plurality of PTO request switches. The method determines if a PTO request signal from at least one of the plurality of PTO request switches is an active PTO request switch. An activation state of a power take off is modified when the PTO request signal is from an active PTO request switch.

[0014] According to another embodiment a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain comprises an internal combustion engine, an electric motor and generator system, a power take off, a controller area network, a body computer, a data link based remote power module, a first PTO driven component, and a second PTO driven component. The power take off is selectively coupled to at least one of the internal combustion engine and the electric motor and generator system to receive torque from at least one of the internal combustion engine and the electric motor and generator system. The body computer is electronically connected to the controller area network to receive a plurality of chassis input signals. The controller area network additionally having an electronic control module, a transmission control module, and a hybrid

control module. The electronic control module is electrically connected to the transmission control module and the hybrid control module. The data link based remote power module is installed on the vehicle for generating body demand signals for initiating operation of the vehicle hybrid electric powertrain for a power take off operation. The first PTO driven component is electrically connected to the controller area network. The second PTO driven component is electrically connected to the controller area network. The body computer is programmable to monitor operation of the first PTO driven component and the second PTO driven component. The body computer is further programmable to monitor which of either the internal combustion engine and the electric motor and generator system is providing torque to the power take off.

[0015] According to another embodiment, a control system for a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain comprises a controller are network, a body computer, an electronic control module, a remote power module, and a plurality of PTO driven components. The controller area network has an electronic control module. The plurality of PTO driven components are electronically connected to the controller area network. The body computer is programmable to accept a signal from the PTO driven components to indicate that a PTO driven component is active.

[0016] According to another process, a method of tracking power take off operation of a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain is provided. Activation of a PTO driven component is monitored using a body computer. Torque delivery from an internal combustion engine and an electric motor and generator system is monitored. The method determines if at least one of the internal combustion engine and the electric motor and generator system are delivering torque to a power take off when the PTO driven component is active. An amount of time a PTO driven component is active is monitored. An amount of torque delivered to the power take off from the internal combustion engine and the electric motor and generator is monitored when the PTO driven component is active.

[0017] According to still another embodiment, a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain comprises an internal combustion engine, an electric motor and generator, a power take off, a controller area network, a body computer, a data link based remote power module, at least one PTO driven component, and an exterior PTO status indicator. The power take off is selectively coupled to at least one of the internal combustion engine and the electric motor and generator system to receive torque from at least one of the internal combustion engine and the electric

motor and generator. The body computer is connected to the controller area network provided to receive a plurality of chassis input signals. The controller area network additionally has an electronic control module, a transmission control module, and a hybrid control module. The electronic control module is electrically connected to the transmission control module and the hybrid control module. The data link based remote power module generates body demand signals to initiate operation of the vehicle hybrid electric powertrain for a power take off operation. The at last one PTO driven component is electrically connected to the controller area network. The exterior power take off status indicator electrically connected to the controller area network.

[0018] According to another embodiment, a control system for a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain comprises a controller area network, at least one PTO driven component, and an exterior power take off status indicator. The controller area network has an electronic control module, a body computer, an electronic control module, a hybrid control module and a remote power module. The at least one PTO driven component is electronically connected to the controller area network. The body computer is programmable to accept a signal from the at least one PTO driven component to indicate that a PTO driven component is active. The exterior power take off status indicator is electrically connected to the controller area network.

[0019] According to another process, a method of providing external indication of power take off operation of a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain is provided. An activation and a deactivation of a PTO driven component is monitored using a body computer. A signal is to an exterior power take off status indicator is generated when the body computer detects that the PTO driven component is at least one of either activated and deactivated. An exterior power take off status indication is provided on the exterior power take off status indicator in response to the signal from the body computer.

[0020] According to another embodiment, a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain comprises a controller area network, a body computer, a data link based remote power module, and a wireless PTO request switch. The body computer connects to the controller area network to receive a plurality of chassis input signals as well as an electronic control module, a transmission control module, and a hybrid control module. The electronic control module is electrically connected to the body computer, the transmission control module and the hybrid control module. The data link based remote power module is provided for generating body

demand signals for initiating operation of the vehicle hybrid electric powertrain for a power take off operation. The remote power module is electrically connected to the controller area network. The wireless PTO request switch is electrically connected to the controller area network via the remote power module. The body computer is programmable to receive a signal from the wireless PTO request switch to change an operating state of the power take off operation. The remote power module cycles off an output to the wireless PTO request switch in response to signal from the wireless PTO request switch to allow a change in power take off operations.

[0021] According to another embodiment, a control system for a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain comprises a controller area network, and a wireless PTO request switch. The controller area network has an electronic control module, a body computer, and a remote power module. The wireless PTO request switch is electrically connected to the controller area network via the remote power module. The body computer is programmable to accept a signal from the wireless PTO request switch to change an operating state of the power take off operation. The remote power module cycles off an output to the wireless PTO request switch in response to signal from the wireless PTO request switch to allow a change in power take off operations.

[0022] According to another process, a method of engaging a power take off using a wireless PTO request switch of a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain is provided. A controller area network having a remote power module is programmed to receive a PTO request signal with the remote power module from a wireless PTO request switch having a transmitter and a receiver. The method determines if the PTO request signal from the wireless PTO request switch seeks a change in power take off operations. An output to the wireless PTO request switch cycles off in response to signal from the wireless PTO request switch to allow a change in power take off operations. An activation state of a power take off is modified following the output to the wireless PTO request switch being cycled off.

.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. 1 is a side elevation of a vehicle equipped for a power take-off operation.

[0024] FIG. 2 is a high level block diagram of a control system for the vehicle of FIG. 1.

[0025] FIG. 3 is a diagram for a state machine relating to a power take-off operation which can be implemented on the control system of FIG. 2.

[0026] Figs. 4A-D are schematic illustrations of a hybrid powertrain applied to support a power take-off operation.

[0027] FIG. 5 is a system diagram for chassis and body initiated hybrid electric motor and generator control for power take-off operation.

[0028] FIG. 6 is a map of input and output pin connections for a remote power module in the system diagram of FIG. 5.

[0029] FIG. 7 is a map of input and output locations for the electrical system controller of FIG. 5.

[0030] FIGS. 8A-D are schematic views of a vehicle having a hybrid-electric powertrain with a PTO driven hydraulic system.

[0031] FIG, 9 is a system diagram for a control system of the vehicle of FIGS. 8A-D.

[0032] FIGS. 10A-D are schematic views of a vehicle having a hybrid-electric powertrain with a PTO driven hydraulic system having an accumulator and an accumulator isolation valve.

[0033] FIG. 11 is a schematic view of a vehicle having a hybrid-electric powertrain with a PTO driven hydraulic system that may be remotely activated.

[0034] FIG. 12 is a schematic view of a vehicle having a hybrid-electric powertrain with a PTO driven hydraulic system whose operation and power source that may be monitored

[0035] FIG. 13 is a schematic view of a vehicle having a hybrid-electric powertrain with a PTO driven hydraulic system whose operational state may be provided to a user through visual or audible signals.

[0036] FIG. 14 is a schematic view of a vehicle having a hybrid-electric powertrain with a PTO driven hydraulic system that may be remotely controlled.

DETAILED DESCRIPTION

[0037] Referring now to the figures and in particular to FIG. 1, a hybrid mobile aerial lift truck 1 is illustrated. Hybrid mobile aerial lift truck 1 serves as an example of a medium duty vehicle which supports a PTO vocation, or an EPTO vocation. It is to be noted that embodiments described herein, possibly with appropriate modifications, may be used with any suitable vehicle. Additional information regarding hybrid powertrains may be found in U.S. Patent No. 7,281,595 entitled "System For Integrating Body Equipment With a Vehicle

Hybrid Powertrain," which is assigned to the assignee of the present application and which is fully incorporated herein by reference.

[0038] The mobile aerial lift truck 1 includes a PTO load, here an aerial lift unit 2 mounted to a bed on a back portion of the truck 1. During configuration for EPTO operation, the transmission for mobile aerial lift truck 1 may be placed in park, the park brake may be set, outriggers may be deployed to stabilize the vehicle, and indication from an onboard network that vehicle speed is less than 5 kph may be received before the vehicle enters PTO mode. For other types of vehicles different indications may indicate readiness for PTO operation, which may or may not involve stopping the vehicle.

[0039] The aerial lift unit 2 includes a lower boom 3 and an upper boom 4 pivotally connected to each other. The lower boom 3 is in turn mounted to rotate on the truck bed on a support 6 and rotatable support bracket 7. The rotatable support bracket 7 includes a pivoting mount 8 for one end of lower boom 3. A bucket 5 is secured to the free end of upper boom 4 and supports personnel during lifting of the bucket to and support of the bucket within a work area. Bucket 5 is pivotally attached to the free end of boom 4 to maintain a horizontal orientation. A lifting unit 9 is connected between bracket 7 and the lower boom 3. A pivot connection 10 connects the lower boom cylinder 11 of unit 9 to the bracket 7. A cylinder rod 12 extends from the cylinder 11 and is pivotally connected to the boom 3 through a pivot 13. Lower boom cylinder unit 9 is connected to a pressurized supply of a suitable hydraulic fluid, which allows the assembly to be lifted and lowered. A source of pressurized hydraulic fluid may be an automatic transmission or a separate pump. The outer end of the lower boom 3 is connected to the lower and pivot end of the upper boom 4. A pivot 16 interconnects the outer end of the lower boom 3 to the pivot end of the upper boom 4. An upper boom compensating cylinder unit or assembly 17 is connected between the lower boom 3 and the upper boom 4 for moving the upper boom about pivot 16 to position the upper boom relative to the lower boom 3. The upper-boom, compensating cylinder unit 17 allows independent movement of the upper boom 4 relative to lower boom 3 and provides compensating motion between the booms to raise the upper boom with the lower boom. Unit 17 is supplied with pressurized hydraulic fluid from the same source as unit 9.

[0040] Referring to FIG. 2, a high level schematic of a control system 21 representative of a system usable with vehicle 1 control is illustrated. An electrical system controller 24, a type of a body computer, is linked by a public datalink 18 (here illustrated as a SAE compliant J1939 CAN bus) to a variety of local controllers which in turn implement direct control over most vehicle 1 functions. Electrical system controller ("ESC") 24 may also be

directly connected to selected inputs and outputs and other busses. Direct "chassis inputs" include, an ignition switch input, a brake pedal position input, a hood position input and a park brake position sensor, which are connected to supply signals to the ESC 24. Other inputs to ESC 24 may exist. Signals for PTO operational control from within a cab may be implemented using an in-cab switch pack(s) 56. In-cab switch pack 56 is connected to ESC 24 over a proprietary data link 64 conforming to the SAE J1708 standard. Data link 64 is a low baud rate data connection, typically on the order of 9.7 Kbaud. Five controllers in addition to the ESC 24 are illustrated connected to the public datalink 18. These controllers are the engine controller ("ECM") 46, the transmission controller 42, a gauge cluster controller 58, a hybrid controller 48 and an antilock brake system controller ("ABS") 50. Other controllers may exist on a given vehicle. Datalink 18 is the bus for a public controller area network ("CAN") conforming to the SAE J1939 standard and under current practice supports data transmission at up to 250 Kbaud. It will be understood that other controllers may be installed on the vehicle 1 in communication with datalink 18. ABS controller 50, as is conventional, controls application of brakes 52 and receives wheel speed sensor signals from sensors 54. Wheel speed is reported over datalink 18 and is monitored by transmission controller 42.

[0041] Vehicle 1 is illustrated as a parallel hybrid electric vehicle which utilizes a powertrain 20 in which the output of either an internal combustion engine 28, an electric motor and generator 32, or both, may be coupled to the drive wheels 26. Internal combustion engine 28 may be a diesel engine. As with other full hybrid systems, the system is intended to recapture the vehicle's inertial momentum during braking or slowing. The electric motor and generator 32 is run as a generator from the wheels, and the generated electricity is stored in batteries during braking or slowing. Later the stored electrical power can be used to run the electric motor and generator 32 instead of or to supplement the internal combustion engine 28 to extend the range of the vehicle's conventional fuel supply. Powertrain 20 is a particular variation of hybrid design which provides support for PTO either from internal combustion engine 28 or from the electric motor and generator 32. When the internal combustion engine 28 is used for PTO it can be run at an efficient power output level and used to concurrently support of PTO operation and to run the electric motor and generator 32 in its generator mode to recharge the traction batteries 34. Usually a PTO application consumes less power than power output at a thermally efficient internal combustion engine 28 throttle setting.

[0042] The electric motor and generator 32 is used to recapture the vehicle's kinetic energy during deceleration by using the drive wheels 26 to drive the electric motor and generator 32. At such times auto-clutch 30 disconnects the engine 28 from the electric motor and generator 32. Engine 28 may be utilized to supply power to both generate electricity and operate PTO system 22, to provide motive power to drive wheels 26, or to provide motive power and to run a generator to generate electricity. Where the PTO system 22 is an aerial lift unit 2 it is unlikely that it would be operated when the vehicle was in motion, and the description here assumes that in fact that the vehicle will be stopped for EPTO, but other PTO applications may exist where this is not done.

[0043] Powertrain 20 provides for the recapture of kinetic energy in response to the electric motor and generator 32 being back driven by the vehicle's kinetic force. The transitions between positive and negative traction motor contribution are detected and managed by a hybrid controller 48. Electric motor and generator 32, during braking, generates electricity which is applied to traction batteries 34 through inverter 36. Hybrid controller 48 looks at the ABS controller 50 datalink traffic to determine if regenerative kinetic braking would increase or enhance a wheel slippage condition if regenerative braking were initiated. Transmission controller 42 detects related data traffic on datalink 18 and translates these data as control signals for application to hybrid controller 48 over datalink 68. Electric motor and generator 32, during braking, generates electricity which is applied to the traction batteries 34 through hybrid inverter 36. Some electrical power may be diverted from hybrid inverter to maintain the charge of a conventional 12-volt DC Chassis battery 60 through a voltage step down DC/DC inverter 62.

[0044] Traction batteries may be the only electrical power storage system for vehicle 1. In vehicles contemporary to the writing of this application numerous 12 volt applications remain in common use and vehicle 1 may be equipped with a parallel 12 volt system to support the vehicle. This possible parallel system is not shown for the sake of simplicity of illustration. Inclusion of such a parallel system would allow the use of readily available and inexpensive components designed for motor vehicle use, such as incandescent bulbs for illumination. However, using 12 volt components may incur a vehicle weight penalty and involve extra complexity.

[0045] Electric motor and generator 32 may be used to propel vehicle 1 by drawing power from battery 34 through inverter 36, which supplies 3 phase 340 volt rms power. Battery 34 is sometimes referred to as the traction battery to distinguish it from a secondary 12 volt lead acid battery 60 used to supply power to various vehicle systems. However, high

mass utility vehicles tend to exhibit far poorer gains from hybrid locomotion than do automobiles. Thus stored electrical power is also used to power the EPTO system 22. In addition, electric motor and generator 32 is used for starting engine 28 when the ignition is in the start position. Under some circumstances engine 28 is used to drive the electric motor and generator 32 with the transmission 38 in a neutral state to generate electricity for recharging battery 34 and/or engaged to the PTO system 22 to generate electricity for recharging the battery 34 and operate the PTO system 22. This would occur in response to heavy PTO system 22 use which draws down the charge on battery 34. Typically engine 28 has a far greater output capacity than is used for operating PTO system 22. As a result, using it to directly run PTO system 22 full time would be highly inefficient due to parasitic losses incurred in the engine or idling losses which would occur if operation were intermittent. Greater efficiency is obtained by running engine 22 at close to its rated output to recharge battery 34 and provide power to the PTO, and then shutting down the engine and using battery 34 to supply electricity to electric motor and generator 32 to operate PTO system 22.

[0046] An aerial lift unit 2 is an example of a system which may be used only sporadically by a worker first to raise and later to reposition its basket 5. Operating the aerial lift unit 2 using the traction motor 32 avoids idling of engine 28. Engine 28 runs periodically at an efficient speed to recharge the battery if battery 34 is in a state of relative discharge. Battery 34 state of charge is determined by the hybrid controller 48, which passes this information to transmission controller 42 over datalink 68. Transmission controller 42 can in turn can request ESC 24 to engage engine 28 by a message to the ESC 24, which in turn sends engine operation requests (i.e. engine start and stop signals) to ECM 46. The availability of engine 28 may depend on certain programmed (or hardwired) interlocks, such as hood position.

[0047] Powertrain 20 comprises an engine 28 connected in line with an auto clutch 30 which allows disconnection of the engine 28 from the rest of the powertrain when the engine is not being used for motive power or for recharging battery 34. Auto clutch 30 is directly coupled to the electric motor and generator 32 which in turn is connected to a transmission 38. Transmission 38 is in turn used to apply power from the electric motor and generator 32 to either the PTO system 22 or to drive wheels 26. Transmission 38 is bi-directional and can be used to transmit energy from the drive wheels 26 back to the electric motor and generator 32. Electric motor and generator 32 may be used to provide motive energy (either alone or in cooperation with the engine 28) to transmission 38. When used as a generator the electric

motor and generator supplies electricity to inverter 36 which supplies direct current for recharging battery 34.

[0048] A control system 21 implements cooperation of the control elements for the operations just described. ESC 24 receives inputs relating to throttle position, brake pedal position, ignition state and PTO inputs from a user and passes these to the transmission controller 42 which in turn passes the signals to the hybrid controller 48. Hybrid controller 48 determines, based on available battery charge state, whether the internal combustion engine 28 or the traction motor 32 satisfies requests for power. Hybrid controller 48 with ESC 24 generates the appropriate signals for application to datalink 18 for instructing the ECM 46 to turn engine 28 on and off and, if on, at what power output to operate the engine. Transmission controller 42 controls engagement of auto clutch 30. Transmission controller 42 further controls the state of transmission 38 in response to transmission push button controller 72, determining the gear the transmission is in or if the transmission is to deliver drive torque to the drive wheels 26 or to a hydraulic pump which is part of PTO system 22 (or simply pressurized hydraulic fluid to PTO system 22 where transmission 38 serves as the hydraulic pump) or if the transmission is to be in neutral. For purposes of illustration only, a vehicle may come equipped with more than one PTO system, and a secondary pneumatic system using a multi-solenoid valve assembly 85 and pneumatic PTO device 87 is shown under the direct control of ESC 24.

[0049] PTO 22 control is conventionally implemented through one or more remote power modules (RPMs). Remote power modules are data-linked expansion input/output modules dedicated to the ESC 24, which is programmed to utilize them. Where RPMs 40 function as the PTO controller they can be configured to provide hardwire outputs 70 and hardwire inputs used by the PTO device 22 and to and from the load/aerial lift unit 2. Requests for movement from the aerial lift unit 2 and position reports are applied to the proprietary datalink 74 for transmission to the ESC 24, which translates them into specific requests for the other controllers, e.g. a request for PTO power. ESC 24 is also programmed to control valve states through RPMs 40 in PTO device 22. Remote power modules are more fully described in U.S. Pat. No. 6,272,402, which is assigned to the assignee of the present application and which is fully incorporated herein by reference. At the time the '402 patent was written what are now termed "Remote Power Modules" were called "Remote Interface Modules". It is contemplated that the TEMs who provide the PTO vocation will order or equip a vehicle with RPMs 40 to support the PTO and supply a switch pack 57 for connection to the RPM 40. TEMs are colloquially known as “body builders” and signals from an RPM

40 provided for body builder supplied vehicle vocations are termed "body power demand signals".

[0050] Body power demand signals may be subject to corruption, vehicle damage or architectural conflicts over the vehicle controller area network. Accordingly an alternative mechanism is provided to generate power demand signals for the PTO from the vehicle's conventional control network. A way of providing for operator initiation of such a power demand signal without use of RPM 40 is to use the vehicle's conventional controls including controls which give rise to what are termed "chassis inputs". Power demand signals for PTO operation originating from such alternative mechanisms are termed "chassis power demand signals". An example of such could be flashing the headlamps twice while applying the parking brake, or some other easy to remember, but seemingly idiosyncratic control usage, so long as the control choice does not involve the PTO dedicated RPM 40.

[0051] Transmission controller and ESC 24 both operate as portals and/or translation devices between the various datalinks. Proprietary datalinks 68 and 74 operate at substantially higher baud rates than does the public datalink 18, and accordingly, buffering is provided for a message passed from one link to another. Additionally, a message may be reformatted, or a message on one link may be changed to another type of message on the second link, e.g. a movement request over datalink 74 may translate to a request for transmission engagement from ESC 24 to transmission controller 42. Datalinks 18, 68 and 74 are all controller area networks and conform to the SAE J1939 protocol. Datalink 64 conforms to the SAE J1708 protocol.

[0052] Referring to FIG. 3 a representative state machine 300 is used to illustrate one possible control regime. State machine 300 is entered through either of two EPTO enabled states 300, 302, depending upon whether engine 28 is operating to recharge the traction batteries 34 or not. In the EPTO enabled state the conditions triggering EPTO operation have been met, but the actual PTO vocation is not powered. Depending upon the state of charge of the traction batteries 34, engine 28 may be operating (state 302) or may not be running (state 304). In any state where the engine 28 is on the auto clutch 30 is engaged (+). The state of charge which initiates battery charging is less than the state of charge at which charging is discontinued to prevent frequent cycling of the engine 28 on and off. The EPTO enabled states (302, 304) provide that the transmission 38 is disengaged. In state 302 where batteries 34 are being charged, the electric motor and generator 32 is in its generator mode. In state 304 where batteries 34 are considered charged, the state of the electric motor and generator 32 need not be defined and may be left in its prior state.

[0053] Four EPTO operating states, 306, 308, 310 and 312 are defined. These states occur in response to either a body power demand or chassis power demand. Within PTO vehicle battery charging continues to function. State 306 provides that the engine 28 be on, the auto clutch 30 be engaged, the electric motor and generator 32 be in its generator mode and the transmission be in gear for PTO. In state 308 the engine 28 is off, the auto clutch 30 is disengaged, the traction motor is in its motor mode and running and the transmission 38 be in gear for PTO. States 306 and 308, as a class, are exited upon loss of the body power demand signal (which may occur as a result of cancellation of PTO enable) or upon or occurrence of a chassis power demand signal. Changes in state stemming from the battery state of charge can force changes within the class between states 306 and 308. EPTO operating states 310 and 312 are identical to states 306 and 308, respectively, except that loss of the body power demand signal does not result in one of states 310, 312 being exited. Only loss of the chassis power demand signal results in exit from EPTO operating states 310 or 312, taken as a class, although transitions within the class (i.e. between 310 and 312) can result from the battery state of charge. Upon loss of a chassis power demand signal the exit route from states 310, 312, depends upon whether a body power demand signal is present. If it is the operational state moves from states 310 or 312 to states 306 or 308, respectively. If it is not, then to states 302 or 304. If the body power demand signal was lost due to exit from the EPTO enable conditions than states 302 or 304 are exited along the "OFF" routes. For transitions within a class, particularly from an engine 28 off to an engine 28 on state, an intermediary state may be provided where the auto-clutch 30 is engaged to permit the traction motor to crank the engine.

[0054] Figs. 4A-D illustrate graphically what occurs on the vehicle in the various states of the state machine implemented through appropriate programming of the ESC 24. FIG. 4A corresponds to state 304, one of the EPTO enabled state. FIG. 4B corresponds to state 302, the other EPTO enabled state. FIG. 4C corresponds to states 308 and 312, while FIG. 4D corresponds to states 306 and 310. In FIG. 4A the IC engine 28 is off (state 100), the auto clutch is disengaged (state 102), the electric motor and generator 32 state may be undefined, but is shown as being motor mode (104). With electric motor and generator 32 in the motor mode the battery is shown in a discharge ready state 108. The transmission is shown as in gear (106), though this is elective. In FIG. 4B battery charging 128 is occurring as a result of the IC engine running 120, the auto clutch being engaged 122 with engine torque being applied through the auto clutch to the electric motor and generator 32 operating in its generator mode 124. The transmission is out of gear 126.

[0055] FIG. 4C corresponds to state machine 300 states 308 and 312 with the engine 28 being off 100, the auto clutch 30 being disengaged 102. The battery 34 is discharging 108 to operate the traction motor in its running state 104 to apply torque to the transmission 38 which is in gear 126 to apply drive torque to the PTO. FIG. 4D corresponds to state machine 300 states 306 and 310. The IC engine 28 is running 120 to supply power through an engaged 122 auto clutch to operate the electric motor and generator 32 in it generator mode to supply electrical power to a charging (128) battery and to supply torque through the transmission to the PTO application.

[0056] Figs. 5-7 illustrate a specific control arrangement and network architecture on which the state machine 300 may be implemented. Additional information regarding control systems for hybrid powertrains may be found in U.S. Patent Application Serial No. 12/239,885 filed on September 29, 2008 and entitled "Hybrid Electric Vehicle Traction Motor Driven Power take off Control System" which is assigned to the assignee of the present application and which is fully incorporated herein by reference, as well as U.S. Patent Application Serial No. 12/508,737 filed on July 24, 2009, which is assigned to the assignee of the present application and which is fully incorporated herein by reference. The arrangement also provides control over a secondary pneumatic power take-off operation 87 to illustrate that conventional PTO may be mixed with EPTO on a vehicle. Electrical system controller 24 controls the secondary pneumatic PTO 87 using a multiple solenoid valve assembly 85. Available air pressure may dictate control responses and accordingly an air pressure transducer 99 is connected to provide air pressure readings directly as inputs to the electrical system controller 24. Alternatively, EPTO could be implemented using the pneumatic system if the traction motor PTO were an air pump.

[0057] The J1939 compliant cable 74 connecting ESC 24 to RPM 40 is a twisted pair of cables. RPM 40 is shown with 6 hardwire inputs (A-F) and one output. A twisted pair cable 64 conforming to the SAE J1708 standard connects ESC 24 to a inlay 64 for the cab dash panel on which various control switches are mounted. The public J1939 twisted pair cable 18 connects ESC 24 to the gauge controller 58, the hybrid controller 48 and the transmission controller 42. The transmission controller 42 is provided with a private connection to the cab mounted transmission control console 72. A connection between the hybrid controller 48 and the console 72 is omitted in this configuration though it may be provided in some contexts.

[0058] FIG. 6 illustrates in detail the input and output pin usage for RPM 40 for a specific application. Input pin A is the Hybrid Electric Vehicle demand circuit 1 input which can be a 12 volt DC or ground signal. When active the traction motor runs continuously.

Input pin B is the Hybrid Electric Vehicle demand circuit 2 input which can be a 12 volt DC or ground signal. When active, the traction motor runs continuously. Input pin C is the Hybrid Electric Vehicle demand circuit 3 input which can be a 12 volt DC or ground signal. When the signal is active the traction motor runs continuously. Input pin D is the Hybrid Electric Vehicle demand circuit 4 input which can be a 12 volt DC or ground signal. When the signal is active the traction motor runs continuously. In other words the designer can provide four remote locations for switches from which an operator can initiate a PTO body power demand signal to operate the traction motor. Input pin E is a hybrid electric vehicle remote PTO disable input. The signal can be either 12 volts DC or ground. When active PTO is disabled. Input pin F is the hybrid electric vehicle EPTO engaged feedback signal. This signal is a ground signal originating with a PTO mounted pressure or ball detent feedback switch. The output pin carries the actual power demand signal. As noted this may be subject to various interlocks. In the example the interlock conditions are that measured vehicle speed be less than 3 miles per hour, the gear setting be neutral and the park brake set.

[0059] FIG. 7 illustrates the location of chassis output pins and chassis input pins on the electrical system controller 24.

[0060] The system described here provides a secondary mechanism for controlling the hybrid electric motor and generator through the use of various original equipment manufacturer (OEM) chassis inputs, circumventing the TEMs' input (demand) signal sourcing devices (e.g. the RPM 40). Initiating this mode of operation can be made as simple as desired by use of a single in-cab mounted switch, which may be located in the switch pack 56, or which may be made more complex and less obvious by using a sequence of control inputs to operate as a "code". For example, with the vehicle in EPTO mode, the service brake could be depressed and held and the high beams flashed on and off twice. Once the service brake is released subsequent activations of the high beams could generate a signal for toggling the traction motor's operation. In any event, when the traction motor is under the control of "chassis initiated" inputs. TEM input states are ignored or circumvented.

[0061] Turning now to FIGS. 8A-D, a hybrid-electric powertrain with a PTO driven hydraulic system 800 is shown. The hybrid-electric powertrain with a PTO driven hydraulic system 800 comprises an internal combustion engine 802, an electric motor and generator 803, a PTO 804, and a first hydraulic pump 806 and a second hydraulic pump 808. The PTO 804 is adapted to receive power from either the internal combustion engine 802 or the electric motor and generator 803. The PTO 804 drives the first hydraulic pump 804 and the second hydraulic pump 808.

[0062] As shown in FIGS. 8A-D, the first hydraulic pump 806 is a fixed displacement hydraulic pump, such as a vane pump, while the second hydraulic pump 808 is a variable displacement hydraulic pump, such as a piston pump.

[0063] The second hydraulic pump 808 has a control motor 810 and/or a control solenoid 812 to control the adjustment of the variable displacement setting of the second hydraulic pump 808. The control motor 810 may be a an electric motor, an electro-magnet stepper motor, or the like. The control solenoid 812 may be a an elecrto-magnetic solenoid device or the like.

[0064] It is contemplated that the internal combustion engine 802 may be utilized to drive the PTO 804 to power the first hydraulic pump 806, while the electric motor and generator 803 is typically utilized to power the second hydraulic pump 808. The use of the first hydraulic pump 806 or the second hydraulic pump 808 often depends on a load level placed on a hydraulic system 805. A large hydraulic load will utilize the first hydraulic pump 806 driven by the internal combustion engine 802, while a small hydraulic load will utilize the second hydraulic pump 808 driven by the electric motor and generator 803.

[0065] The internal combustion engine is adapted to supply torque to the hydraulic pumps 806, 808 at engine speeds from about 700 RPM to about 2000 RPM. However, the electric motor and generator 803 produces a high torque level at operating speeds of less than about 1500 RPM. Therefore, when the electric motor and generator 803 is being utilized to run the second hydraulic pump 808 via the PTO 804, displacement of the second hydraulic pump is adjusted to a larger displacement if the hydraulic load on the hydraulic system 805 requires the electric motor and generator 803 to operate at a speed above 1500 RPM. The control motor 810 and/or the control solenoid 812 increase the displacement of the second pump 808such that electric motor and generator 803 may supply sufficient hydraulic fluid flow and pressure to the hydraulic system 805, while also operating at a speed of less than 1500 RPM.

[0066] Similarly, if the load within the hydraulic system 805 decreases, the displacement of the second hydraulic pump 808 may be adjusted to a smaller displacement, and the electric motor and generator 803 may be slowed to an speed below 1500 RPM.

[0067] In addition to adjusting the displacement of the second hydraulic pump 808 when the load of the hydraulic system 805 changes to a load that requires the electric motor and generator to operate a speed above 1500 RPM, it is also contemplated that the second hydraulic pump 808 may be adjusted by the control motor 810 and/or the control solenoid 812 to a displacement that allows the electric motor and generator to operate at a higher level

of efficiency. For example, if the electric motor and generator produces torque most efficiently at a speed of 1300 RPM, the displacement of the second hydraulic pump 808 may be adjusted so that the load of the hydraulic system 805 is met by the second hydraulic pump 808, while the electric motor and generator is operating at the speed of 1300 RPM.

[0068] The hydraulic system 805 depicted in FIGS. 8A-D further comprises a reservoir 814 that contains hydraulic fluid used in the hydraulic system 805. The reservoir is in fluid communication with hydraulic motors 816, hydraulic cylinders 817, and hydraulic valves 818 of the hydraulic system, providing the necessary fluid to operate the hydraulic motors 816, hydraulic cylinders 817, and hydraulic valves 818.

[0069] The electric motor and generator 803 is connected to a battery 820 and an electrical controller 822. The battery 820 stores electrical power for use by the electric motor and generator 803. The electrical controller 822 regulates electrical energy between the battery 820 and the electrical motor and generator 803.

[0070] Turning now to FIG. 9, a specific control arrangement and network architecture 900 on which the hybrid-electric powertrain with a PTO driven hydraulic system 800 state may be implemented. A first remote throttle 902 and/or a second remote throttle 904 are provided on TEM components to give a user the ability to control the output of the electric motor and generator 803 or the internal combustion engine 802 in order to control the hydraulic system 805. The first remote throttle 902 is a variable pedal throttle, while the second remote throttle 904 is a hand operated vernier throttle.

[0071] As shown in FIG. 9, the first remote throttle is electrically connected to the Engine Control Module, or Electronic Control Module, ("ECM") 906. The second remote throttle 904 may be electrically connected to the ECM 906 via a remote engine speed control module ("RESCM") 908 or a remote power module 910. The RESCM 908 and the remote power module 910 are electronically connected to an Electronic System Controller ("ESC") 912 via a J1939 compliant cable 914.

[0072] The ESC 912 is electronically connected to the ECM 906 via a J1939 compliant cable 916. The J1939 compliant cable 916 additionally connects a gauge cluster 918, a hybrid control module 920, and a transmission control module 922 to the ECM 906. The ESC 912 monitors the internal combustion engine 802 and the electric motor and generator 803 as well as the demand of the hydraulic system 805 and input from the first remote throttle 904 and/or the second remote throttle 906, and generates control signals adapted to control the internal combustion engine 802 and the electric motor and generator 803. The demand of

the hydraulic system 805 is greatly influenced by the input from the first remote throttle 904 and/or the second remote throttle 906.

[0073] The ESC 912 will generate speed commands for the internal combustion engine 802 and/or the electric motor and generator 803 such that the first hydraulic pump 804 and/or the second hydraulic pump 806 fulfill the demand of the hydraulic system 805. For instance, the ESC 912 may generate a signal that increases or decreases the speed of the electric motor and generator 803 in order to provide sufficient hydraulic fluid flow from the second hydraulic pump 806. Similarly, the ESC 912 may generate a signal that increases or decreases the speed of the internal combustion engine 802 in order to provide sufficient hydraulic fluid flow from the first hydraulic pump 804.

[0074] The ESC 912 additionally generates an output signal that is transmitted to the second hydraulic pump 806 in the event the displacement of the second hydraulic pump 806 is to be modified. If a hydraulic load is above a predetermined threshold, the displacement of the second hydraulic pump 806 maybe For instance, if the electric motor and generator 803 is being used to power the second hydraulic pump, and the speed of the electric motor and generator 803 is approaching 2000 RPM, the ESC 912 generates an output signal that causes the control motor 810 or the control solenoid 812 to increase the displacement of the second hydraulic pump 806, such that the output of the second hydraulic pump 806 is increased, and the speed of the electric motor and generator 803 is maintained in a proper operating range.

[0075] It is additionally contemplated that both the first hydraulic pump 804 and the second hydraulic pump 806 may be used simultaneously. In such a configuration the ESC 912 generates an output signal to the control motor 810 or the control solenoid 812 in order to vary the displacement of the second hydraulic pump 806. In such a configuration, a smaller first hydraulic pump 804 may be utilized, as the second hydraulic pump 806 will provide additionally pumping capacity to satisfy the demands of the hydraulic system 805.

[0076] The hydraulic system 805 of the present embodiment may be utilized to power variable speed applications, such as digger derricks, pressure diggers, document shredders, and other variable speed devices.

[0077] Additionally, the use of the a variable displacement second hydraulic pump 806 enhances energy utilization by the hybrid-electric powertrain with a PTO driven hydraulic system 800, as the engine 802 and/or the electric motor and generator 803 may be operated at more efficient settings. Therefore, fuel usage, or electric power required, will be lowered.

[0078] Turning next to FIGS. 10A-D a hydraulic hybrid powertrain 1000 is shown. The hydraulic hybrid powertrain 1000 comprises an internal combustion engine 1002 a hydraulic

pump 1004 connected to and driven by a PTO 1003. The PTO may be powered by the internal combustion engine 1002, or may be a PTO has described above that may be powered by an electric motor and generator 1005 and/or the internal combustion engine 1002.

[0079] The hydraulic hybrid powertrain 1000 additionally comprises a hydraulic accumulator 1006 disposed in fluid communication with the hydraulic pump 1004.

[0080] The hydraulic accumulator 1006 is adapted to store pressurized hydraulic fluid from the hydraulic pump 1004. A hydraulic reservoir 1007 additionally is provided in fluid communication with the hydraulic pump 1004. The hydraulic reservoir 1007 stores low pressure hydraulic fluid that may be pressurized by the hydraulic pump 1004.

[0081] An accumulator isolation valve 1008 is disposed at an outlet of the hydraulic accumulator 1006. The accumulator isolation valve 1008 controls the flow of hydraulic fluid from the hydraulic accumulator 1006. An accumulator solenoid 1010 positions the accumulator isolation valve 1008 between at least a first position that allows hydraulic fluid to flow from the hydraulic accumulator 1006 and a second position that prevents hydraulic fluid from flowing from the hydraulic accumulator 1006. It is contemplated that the accumulator solenoid 1010 may also position the accumulator isolation valve 1008 at a variety of intermediate positions between the first position and the second position to control the flow of hydraulic fluid from the hydraulic accumulator 1006.

[0082] An accumulator transducer 1012 is disposed in fluid communication with the hydraulic accumulator 1006. The accumulator transducer 1012 provides an output signal to monitor the pressure within the hydraulic accumulator 1012. The accumulator transducer 1012 may6 be utilized to control operation of the hydraulic pump 1004 such that pressure within the hydraulic accumulator 1006 may be maintained at operating levels, yet the hydraulic pump 1004 may only be operated intermittently.

[0083] The hydraulic hybrid powertrain 1000 additionally comprises vehicle hydraulic system 1013. The vehicle hydraulic system 1013 may comprise an open center hydraulic system 1015a, a closed center hydraulic system 1015b, or both the open center hydraulic system 1015a, and the closed center hydraulic system 1015b.

[0084] The vehicle hydraulic system 1013 comprises a vehicle hydraulic component transducer 1014. The vehicle hydraulic component transducer 1014 generates an output signal in response to a hydraulic load within the vehicle hydraulic system. The vehicle hydraulic component transducer 1014 is in electrical communication with an ESC 1016. The ESC 1016 is in electrical communication with a RPM 1018, an ECM 1024, an operator display 1026, and a gauge cluster 1028.

[0085] The ESC 1016 monitors the output of the hydraulic component transducer 1014 and causes the RPM 1018 to generate an output signal 1022 that is transmitted to the accumulator solenoid 1010 to position the accumulator isolation valve 1008. The RPM 1018 additionally is adapted to receive input signals 1020 from vehicle hydraulic system 1013 indicating that the vehicle hydraulic system 1013 has been activated. The RPM 1018 may thus generate the output signal 1022 that is transmitted to the accumulator solenoid 101 to position the accumulator isolation valve 1008. It is contemplated that the input signals 1020 from the vehicle hydraulic system 1013 may be utilized generate the output signal 1022 to control an initial opening of the accumulator isolation valve 1008. It is contemplated that the input signals from the vehicle hydraulic component transducer 1014 may be utilized to generate the output signal 1022 to control the closing of the accumulator isolation valve 1008 when no hydraulic load is present within the vehicle hydraulic system 1013.

[0086] The ESC 1016 may also be utilized to reduce the speed of the internal combustion engine 1002, or even shut off the engine 1002, when no hydraulic load is present within the vehicle hydraulic system 1013, by communicating with the ECM 1024. Similarly, the ESC 1016 may be utilized to increase the speed of the internal combustion engine 1002 via the ECM 1024 if the load present within the vehicle hydraulic system 1013 is not being met by the hydraulic pressure within the hydraulic accumulator 1006 and the hydraulic pump 1004 is required to raise the pressure with in the hydraulic accumulator 1006.

[0087] The accumulator transducer 1012 may be used to generate a message on the operator display 1026, or cause an indication on the gauge cluster 1028, such that an operator may know the state of the hydraulic accumulator 1006.

[0088] The accumulator isolation valve 1008 reduces internal parasitic leakage within the vehicle hydraulic system 1013 by preventing hydraulic fluid from the hydraulic accumulator 1006 to flow past the closed accumulator isolation valve 1008

[0089] Turning now to FIG. 11 a hybrid-electric powertrain with a PTO driven hydraulic system 1100 is shown. The hybrid-electric powertrain with a PTO driven hydraulic system 1100 comprises an internal combustion engine 1102, an electric motor and generator 1103, a PTO 1104, and a first hydraulic pump 1106 and a second hydraulic pump 1108. The PTO 1104 is adapted to receive power from either the internal combustion engine 1102 or the electric motor and generator 1103. The PTO 1104 drives the first hydraulic pump 1106 and the second hydraulic pump 1108.

[0090] As shown in FIG. 11, the first hydraulic pump 1106 is a fixed displacement hydraulic pump, such as a vane pump, while the second hydraulic pump1108 is a variable displacement hydraulic pump, such as a piston pump.

[0091] It is contemplated that the internal combustion engine 1102 may typically be utilized to drive the PTO 1104 to power the first hydraulic pump 1106, while the electric motor and generator 1103 is typically utilized to power the PTO 1104 to drive the second hydraulic pump 1108. The use of the first hydraulic pump 1106 or the second hydraulic pump 1108 often depends on a load level placed on a hydraulic system 1105. A large hydraulic load will utilize the first hydraulic pump 1106 driven by the internal combustion engine 1102, while a small hydraulic load will utilize the second hydraulic pump 1108 driven by the electric motor and generator 1103.

[0092] The PTO 1104 has a first PTO shift mechanism 1110 a second PTO shift mechanism 1111 and a third PTO shift mechanism 1112 adapted to allow the engagement and disengagement of the PTO 1104. The first PTO shift mechanism 1110 and the second PTO shift mechanism 1111 are located at the PTO 1104, while the third PTO shift mechanism 1112 is located remotely of the PTO 1104.

[0093] The hydraulic system 1105 depicted in FIG. 11 further comprises a reservoir 1114 that contains hydraulic fluid used in the hydraulic system 1105. The reservoir is in fluid communication with a hydraulic motor 1116, hydraulic valves 1117, and hydraulic cylinders 1118 of the hydraulic system 1105, providing the necessary fluid to operate the hydraulic motor 1116, hydraulic cylinders 1118, and hydraulic valves 1117.

[0094] FIG. 11 also shows a control arrangement 1120 of the hybrid-electric powertrain with the PTO driven hydraulic system 1100. The control arrangement 1120 has a first PTO request switch 1122. The first PTO request switch 1122 is disposed in a cab of a vehicle having the hybrid-electric powertrain with the PTO driven hydraulic system 1100. The first PTO request switch 1122 may be a transmission shift console mounted membrane type switch. The first PTO request switch 1122 requires an operator to be within the cab of the vehicle in order to activate the PTO 1104. A second PTO request switch 1124 is disposed in communication with a RPM 1126. The RPM 1126 is electrically connected to an ESC 1128 via a J1939 compliant cable 1130. The ESC 1128 is electrically connected to an ECM 1132 via J1939 cable 1134. A transmission control module 1136, and a hybrid control module 1138 additionally connect to the cable 1134, and therefore are also electrically connected to the ECM 1132 and the ESC 1128. The second PTO request switch 1124 is mounted on TEM produced equipment. An example of an application for the second PTO request switch 1124

would be utilized is in aviation refueling, where PTO controls are often hardwired onto TEM fueling equipment mounted to a truck.

[0095] A third PTO request switch 1140 is also provided. The third PTO request switch 1140 is a wireless-type request switch that communicates with a receiver 1142. The receiver 1142 is electrically connected to the RPM 1126. Examples of applications where the third PTO request switch 1140 would be utilized include utility operations, recovery operations, and hazardous material handling operations, or other applications where safety may dictate that an operator remain a distance from a vehicle.

[0096] The control arrangement 1120 thus offers a variety of ways in which the PTO 1104 may be activated and deactivated using at least one of the PTO request switches 1122, 1124, 1140. It is contemplated that the control arrangement may be programmed to allow only certain of the PTO request switches 1122, 1124, 1140 to control the PTO 1104. For example, it is contemplated that in some embodiments, only the in-cab PTO request switch 1122 is active to control the PTO 1104, while in other embodiments multiple PTO request switches, such as the first PTO request switch 1122 and the third PTO request switch 1140 are both active to control the PTO 1104. It is also contemplated that the control arrangement 1120 is reprogrammable, such that different PTO request switches 1122, 1124, 1140 may be allowed to control the PTO 1104. For example, the control arrangement 1120 may be programmed so that only the first PTO request switch 1122 is active, only the second PTO request switch 1124 is active, or only the third PTO request switch 1140 is active, while the other PTO request switches are inactive. Alternatively, the control arrangement 1120 may be programmed so that the first PTO request switch 1122 is a primary PTO 1104 activation control, while at least one of the second and third PTO request switch 1124, 1140 serve as a secondary PTO 1104 activation control. Similarly, the control arrangement 1120 may be programmed so that at least one of the second and third PTO request switch 1124, 1140 serve as a primary PTO 1104 activation control, while the first PTO request switch serves as a secondary PTO 1104 activation control. According to a further embodiment, the control arrangement 1120 may be programmed so that any of the PTO request switches 1122, 1124, and 1140 may be the primary PTO 1104 activation control, while the other of the PTO request switched 1122, 1124, and 1140 serve as secondary PTO 1104 activation controls.

[0097] Thus, the PTO 1104 of the hybrid-electric powertrain with a PTO driven hydraulic system 1100 may be engaged, disengaged, or reengaged from more than one location. Such operation is useful when an operator may need to move about a vehicle in order to operate a PTO driven accessory. For example, an operator could engage the PTO 1104 at one of the

second or third PTO request switches 1122, 1140 and then deactivate the PTO 1104 at the first PTO request switch 1122. As the control arrangement 1120 is reconfigurable, the PTO request switches 1122, 1124, 1140 that are active may be reprogrammed based on the current use of the vehicle.

[0098] By integrating ECM 1132, transmission control module 1136, hybrid control module 1138, and ESC 1128 operation of the hybrid-electric powertrain with a PTO driven hydraulic system 1100, ties together operation of the engine 1102, the electric motor and generator 1103, and TEM equipment, such as the hydraulic motor 1116. Thus, the operation of the PTO 1104 may cause the engine 1102, the electric motor and generator 1103 to operate such that the power source for the PTO 1104 is selected based on the load placed on the system from the hydraulic pumps 1106, 1108.

[0099] FIG. 12 shows a hybrid-electric powertrain with a PTO driven hydraulic system 1200. The hybrid-electric powertrain with a PTO driven hydraulic system 1200 comprises an internal combustion engine 1202, an electric motor and generator 1203, a PTO 1204, a first hydraulic pump 1206 and a second PTO driven component 1208, which may be another hydraulic pump. The PTO 1204 is adapted to receive power from either the internal combustion engine 1202, the electric motor and generator 1203, or both the engine 1202 and the electric motor and generator 1203. The PTO 1204 drives the first hydraulic pump 1206, the second PTO driven component 1208.

[00100] It is contemplated that the internal combustion engine 1202 may typically be utilized to drive the PTO 1204 to power the first hydraulic pump 1206 when hydraulic demand is high, while the electric motor and generator 1203 is typically utilized to power the PTO 1204 to drive the first hydraulic pump 1206 while hydraulic demand is low, while one or both of the internal combustion engine 1202 and the electric motor and generator 1203 will be utilized to power the second PTO driven component 1208.

[00101] The PTO 1204 has a first PTO shift mechanism 1210 a second PTO shift mechanism 1211 adapted to allow the engagement and disengagement of the PTO 1204 and PTO driven components 1206, 1208.

[00102] FIG. 12 also shows a control arrangement 1220 of the hybrid-electric powertrain with the PTO driven hydraulic system 1200. The control arrangement 1220 monitors operation of the internal combustion engine 1202 and the electric motor and generator 1203 as well as the PTO 1204 and the PTO driven components 1206, 1208. The first PTO shift mechanism provides a first feedback signal 1222 to an RPM 1224. The RPM 1224 is electrically connect to in electrical communication to an ESC 1226 via a J1939 compliant

cable 1228. The ESC 1226 is electrically connected to an ECM 1230 via J1939 cable 1232. A transmission control module 1234, and a hybrid control module 1236 additionally connect to the cable 1232, and therefore are also electrically connected to the ECM 1230 and the ESC 1226. The second PTO shift mechanism 1211 provides a second feedback signal 1238 directly to the ESC 1226.

[00103] The first feedback signal 1222 and the second feedback signal 1238 allow the control arrangement 1220 to monitor the amount of time that the PTO driven components 1206, 1208 are active. Thus, whenever either of the PTO driven components 1206, 1208 are in use, the control arrangement 1220 will note which of the PTO driven component 1206, 1208 is active, and the length of time the PTO driven component 1206, 1208 is active.

[00104] Alternatively, air solenoids 1240a, 1240b may generate output signals 1242a, 1242b that are in electrical communication with the ESC 1226. The air solenoids 1240a, 1240b may be utilized by systems that utilize pneumatic pressure to activate and deactivate the PTO shift mechanisms 1210, 1211.

[00105] The ESC 1226 additionally monitors output of the ECM 1230 and the hybrid control module 1236 to determine an amount of torque being output by one, or both of the internal combustion engine 1202 and the electric motor and generator 1203 that are being used to power the PTO 1204. Thus, the ESC 1226 can track a percentage of torque being utilized by the PTO 1204 is coming from the internal combustion engine 1202 and which percentage of torque is coming from the electric motor and generator 1203. By monitoring the percentage of torque coming from the internal combustion engine 1202 and the percentage of torque coming from the electric motor and generator 1203 allows the control arrangement 1220 to track all utilization of the PTO 1204, not just those from the internal combustion engine.

[00106] A display 1244 may visually depict the information collected by the ESC 1226 regarding the amount of time the PTO 1204 is active, as well as the percent of torque supplied to the PTO 1204 from the internal combustion engine 1202 and the percent of torque supplied to the PTO 1204 that comes from the electric motor and generator 1203. Additionally, this ESC 1226 may supply the information regarding the amount of time the PTO 1204 is active, as well as the percent of torque supplied to the PTO 1204 from the internal combustion engine 1202 and the percent of torque supplied to the PTO 1204 that comes from the electric motor and generator 1203 via a transmitter 1246 such that remote tracking of the PTO 1204 operations may be performed.

[00107] Turning to FIG. 13 a hybrid-electric powertrain with a PTO driven hydraulic system 1300 is shown. The hybrid-electric powertrain with a PTO driven hydraulic system 1300 comprises an internal combustion engine 1302, an electric motor and generator 1303, a PTO 1304, and a first hydraulic pump 1306 and a second hydraulic pump 1308. The PTO 1304 is adapted to receive power from either the internal combustion engine 1302 or the electric motor and generator 1303. The PTO 1304 drives the first hydraulic pump 1306 and the second hydraulic pump 1308.

[00108] As shown in FIG. 13, the first hydraulic pump 1306 is a fixed displacement hydraulic pump, such as a vane pump, while the second hydraulic pump1308 is a variable displacement hydraulic pump, such as a piston pump.

[00109] It is contemplated that the internal combustion engine 1302 may typically be utilized to drive the PTO 1304 to power the first hydraulic pump 1306, while the electric motor and generator 1303 is typically utilized to power the PTO 1304 to drive the second hydraulic pump 1308. The use of the first hydraulic pump 1306 or the second hydraulic pump 1308 often depends on a load level placed on a hydraulic system 1305. A large hydraulic load will utilize the first hydraulic pump 1306 driven by the internal combustion engine 1302, while a small hydraulic load will utilize the second hydraulic pump 1308 driven by the electric motor and generator 1303.

[00110] The hydraulic system 1305 depicted in FIG. 13 further comprises a reservoir 1314 that contains hydraulic fluid used in the hydraulic system 1305. The reservoir is in fluid communication with a hydraulic motor 1316, hydraulic valves 1317, and hydraulic cylinders 1318 of the hydraulic system 1305, providing the necessary fluid to operate the hydraulic motor 1316, hydraulic cylinders 1318, and hydraulic valves 1317.

[00111] FIG. 13 also shows a control arrangement 1320 of the hybrid-electric powertrain with the PTO driven hydraulic system 1300. The control arrangement 1320 has a first PTO request switch 1322. The first PTO request switch 1322 is disposed in a cab of a vehicle having the hybrid-electric powertrain with the PTO driven hydraulic system 1300. The first PTO request switch 1322 may be a transmission shift console mounted membrane type switch. The first PTO request switch 1322 requires an operator to be within the cab of the vehicle in order to activate the PTO 1304. A second PTO request switch 1324 is disposed in communication with a RPM 1326. The RPM 1326 is electrically connected to an ESC 1328 via a J1939 compliant cable 1330. The ESC 1328 is electrically connected to an ECM 1332 via J1939 cable 1334. A transmission control module 1336, and a hybrid control module 1338 additionally connect to the cable 1334, and therefore are also electrically connected to

the ECM 1332 and the ESC 1328. The second PTO request switch 1324 is mounted on TEM produced equipment.

[00112] A third PTO request switch 1340 is also provided. The third PTO request switch 1340 is a wireless-type request switch that communicates with a receiver 1342. The receiver 1342 is electrically connected to the RPM 1326.

[00113] A fourth PTO request switch 1325 may also be provided which is generally identical to the second PTO request switch 1324.

[00114] The control arrangement 1320 thus offers a variety of ways in which the PTO 1304 may be activated and deactivated using at least one of the PTO request switches 1322, 1324, 1325, 1340.

[00115] As the second, third, and fourth PTO request switches 1324, 1340, 1325 are disposed outside of the vehicle with the hybrid-electric powertrain with a PTO driven hydraulic system 1300, an operator needs to be notified that the control arrangement 1320 has detected the request from the PTO request switch 1324, 1340, 1325. A mode selector switch 1340 disposed within a vehicle cab allows at least one of a visual PTO operation indicator 1342 or an audible PTO operation indicator 1344 to be utilized to indicate a change in operation of the PTO 1304, such as the PTO 1304 being activated, or the PTO 1304 being deactivated. The visual PTO indicator 1342 and the audible PTO indicator 1344 are electrically connected to the RPM 1326. For instance, it is contemplated that a light may be utilized as the visual PTO indicator 1342, while a speaker may be utilized for the audible PTO operation indicator 1344. An operator may select the appropriate one of the visual and audile PTO operation indicator 1342, 1344 depending on the environment the vehicle with the hybrid-electric powertrain with a PTO driven hydraulic system 1300 operates. For example, if the vehicle is in a loud environment, a visual PTO indicator 1342 would be more appropriate, while an audible PTO indicator 1344 may be selected if the vehicle is operated in a bright environment.

[00116] It is contemplated that the visual PTO operation indicator 1342 will provide a different indication when the PTO 1304 is activated, such as a solid light, than when the PTO 1304 is deactivated, such as a blinking light. Similarly, it is contemplated that the audible PTO operation indicator 1344 will provide a different indication when the PTO 1304 is activated, such as a continuous tone for a period of time, than when the PTO 1304 is deactivated, such as an intermittent tone.

[00117] It is further contemplated that both the visual PTO indicator 1342 and the audible PTO indicator 1344 will be utilized simultaneously to provide an indication of the state of the PTO 1304.

[00118] FIG. 14 shows a hybrid-electric powertrain with a PTO driven hydraulic system 1400. The hybrid-electric powertrain with a PTO driven hydraulic system 1400 comprises an internal combustion engine 1402, an electric motor and generator 1403, a PTO 1404, and a first hydraulic pump 1406 and a second hydraulic pump 1408. The PTO 1404 is adapted to receive power from either the internal combustion engine 1402 or the electric motor and generator 1403. The PTO 1404 drives the first hydraulic pump 1406 and the second hydraulic pump 1408.

[00119] The hydraulic system 1405 depicted in FIG. 14 further comprises a reservoir 1414 that contains hydraulic fluid used in the hydraulic system 1405. The reservoir is in fluid communication with a hydraulic motor 1416, hydraulic valves 1417, and hydraulic cylinders 1418 of the hydraulic system 1405, providing the necessary fluid to operate the hydraulic motor 1416, hydraulic cylinders 1418, and hydraulic valves 1417.

[00120] FIG. 14 also shows a control arrangement 1420 of the hybrid-electric powertrain with the PTO driven hydraulic system 1400. The control arrangement 1420 has a wireless-type PTO request switch 1422 that communicates with a receiver 1424. The PTO request switch receiver 1424 is disposed in communication with a RPM 1426. The RPM 1426 is electrically connected to an ESC 1428 via a J1939 compliant cable 1430. The ESC 1428 is electrically connected to an ECM 1432 via J1939 cable 1434. A transmission control module 1436, and a hybrid control module 1438 additionally connect to the cable 1434, and therefore are also electrically connected to the ECM 1432 and the ESC 1428.

[00121] The wireless-type PTO request switch 1422 additionally has a PTO engagement switch 1440, an internal combustion engine control switch 1442, and a remote equipment shutdown 1444. In order to utilize the PTO engagement switch 1440, the internal combustion engine control switch 1442, and the remote equipment shutdown 1444, the wireless-type PTO request switch 1422 transmits a signal to the receiver 1424. The RPM 1426 temporarily cycles off the outputs of the RPM 1426 to the receiver 1424, such that the receiver 1424 releases its latched output state, allowing a change in signal from the receiver 1424 to the RPM 1426, such as a signal to shutoff the PTO 1404 from the PTO engagement switch 1440. The control arrangement 1420 ensures that any other necessary interlocks, such as a parking brake being set and a vehicle ignition key being in a predetermined position, are met prior to allowing the output of the RPM 1426 to the receiver 1424 to be cycled off. Thus, if PTO

1404 was shut down based on an interlock condition no longer being met, the PTO request switch 1422 will not be able to reactivate the PTO 1404, assuming that interlock condition is still not met.

[00122] It is contemplated that the output of the RPM 1426 to the receiver 1424 may be cycled off for a period of about 100ms. Such a time period is sufficiently short that an operator is unlikely to be making another control request in that period, and is also sufficiently short that an operator is unlikely to notice any delay in operations of the PTO 1404. Thus, an operator may utilize the PTO request switch 1422 to alter the operating state of the PTO 1404, internal combustion engine 1402, or remote equipment, such as hydraulic motor 1416, without having to enter a vehicle cab.

CLAIMS

What is claimed is:

1. A vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain comprising:

a controller area network;

a body computer connected to the controller area network to receive a plurality of chassis input signals, the controller area network additionally having an electronic control module, a transmission control module, and a hybrid control module, the electronic control module being electrically connected to the transmission control module and the hybrid control module;

a data link based remote power module installed on the vehicle for generating body demand signals for initiating operation of the vehicle hybrid electric powertrain for a power take off operation; and

a plurality of PTO request switches, the PTO request switches being electrically connected to the controller area network, wherein the body computer is programmable to accept a signal from at least one of the PTO request switches to change an operating state of the power take off operation.

2. The vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain of claim 1, wherein the hybrid electric powertrain comprises an internal combustion engine and an electric motor and generator system, and wherein at least one of the internal combustion engine and the electric motor and generator system supplies torque for the power take off operation.

3. The vehicle of claim 2, wherein the vehicle is a parallel-type hybrid electric powertrain having the internal combustion engine connected to the electric motor and generator system to allow operation of the electric motor and generator system concurrently with operation of the power take off operation directly from the internal combustion engine.

4. The vehicle of claim 1, wherein at least one of the PTO request switches is a remote PTO request switch.

5. The vehicle of claim 1, wherein the body computer is programmable to select at least one of the PTO request switches as an active PTO request switch.

6. The vehicle of claim 5, wherein the body computer is programmable to select at least one of the PTO request switches as a primary PTO request switch and at least another of the PTO request switches as a secondary PTO request switch.

7. The vehicle of claim 6, wherein the secondary PTO request switch is operable only to shut off the power take off operation.

8. A control system for a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain, comprising:

a controller area network having an electronic control module, a body computer, and a remote power module; and

a plurality of PTO request switches electronically connected to the controller area network, wherein the body computer is programmable to receive a signal from at least one of the PTO request switch to change an operating state of a power take off operation.

9. The control system of claim 8, wherein at least one of the plurality of PTO request switches is a remote PTO request switch having a receiver electrically connected to the remote power module.

10. The control system of claim 8, wherein at least one of the plurality of PTO request switches is programmed as a primary PTO request switch, and at least one other of the plurality of PTO request switches is programmed as a secondary PTO request switch.

11. The control system of claim 10, wherein the primary PTO request switch is operable to engage the power take off operation and shut off the power take off operation.

12. The control system of claim 11, wherein the secondary PTO request switch is operable to shut off the power take off operation.

13. The control system of claim 10, wherein at least two of the plurality of PTO request switches are primary PTO request switches.

14. A method of engaging a power take off of a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain, the method comprising:

programming a controller area network to accept a PTO request signal from at least one of a plurality of PTO request switches;

determining if a PTO request signal from the at least one of the plurality of PTO request switches is an active PTO request switch; and

modifying an activation state of a power take off when the PTO request signal is from an active PTO request switch.

15. The method of claim 14, wherein at least one of the PTO request switches is a remote PTO request switch.

16. The method of claim 14, wherein at least one of the PTO request switches is a console mounted PTO request switch.

17. The method of claim 14, wherein at least two of the plurality of PTO request switches are active PTO request switches.

18. The method of claim 17, wherein at least one of the active PTO request switches is a primary PTO request switch and at least one of the other of the active PTO switches is a secondary PTO request switch.

19. The method of claim 18, wherein the at least one of the other of the secondary PTO request switches is operable to disengage power take off.

20. The method of claim 14, wherein the PTO request switches communicate via a remote power module to the controller area network.

AMENDED CLAIMS
received by the International Bureau on 14 September 2010 (14.09.2010).

What is claimed is:

1. A vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain comprising:

a controller area network;

a body computer connected to the controller area network to receive a plurality of chassis input signals, the controller area network additionally having an electronic control module, a transmission control module, and a hybrid control module, the electronic control module being electrically connected to the transmission control module and the hybrid control module;

a data link based remote power module installed on the vehicle for generating body demand signals for initiating operation of the vehicle hybrid electric powertrain for a power take off operation;

a plurality of PTO request switches, the PTO request switches being electrically connected to the controller area network, wherein the body computer is programmable to accept a signal from at least one of the PTO request switches to change an operating state of the power take off operation,

wherein the hybrid electric powertrain comprises an internal combustion engine and an electric motor and generator system, and wherein at least one of the internal combustion engine and the electric motor and generator system supplies torque for the power take off operation,

wherein the vehicle is a parallel-type hybrid electric powertrain having the internal combustion engine connected to the electric motor and generator system to allow operation of the electric motor and generator system concurrently with operation of the power take off operation directly from the internal combustion engine, and

wherein at least one of the PTO request switches is a remote PTO request switch.

2. The vehicle of claim 1, wherein the body computer is programmable to select at least one of the PTO request switches as an active PTO request switch.

3. The vehicle of claim 2, wherein the body computer is programmable to select at least one of the PTO request switches as a primary PTO request switch and at least another of the PTO request switches as a secondary PTO request switch.

4. The vehicle of claim 3, wherein the secondary PTO request switch is operable only to shut off the power take off operation.

5. A control system for a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain, comprising:

a controller area network having an electronic control module, a body computer, and a remote power module;

a plurality of PTO request switches electronically connected to the controller area network, wherein the body computer is programmable to receive a signal from at least one of the PTO request switch to change an operating state of a power take off operation; and

wherein at least one of the plurality of PTO request switches is a remote PTO request switch having a receiver electrically connected to the remote power module.

6. The control system of claim 8, wherein at least one of the plurality of PTO request switches is programmed as a primary PTO request switch, and at least one other of the plurality of PTO request switches is programmed as a secondary PTO request switch.

7. The control system of claim 6, wherein the primary PTO request switch is operable to engage the power take off operation and shut off the power take off operation.

8. The control system of claim 7, wherein the secondary PTO request switch is operable to shut off the power take off operation.

9. The control system of claim 6, wherein at least two of the plurality of PTO request switches is primary PTO request switches.

10. A method of engaging a power take off of a vehicle equipped for power take off operation using direct application of power from a hybrid electric powertrain, the method comprising:

programming a controller area network to accept a PTO request signal from at least one of a plurality of PTO request switches;

determining if a PTO request signal from the at least one of the plurality of PTO request switches is an active PTO request switch; and

modifying an activation state of a power take off when the PTO request signal is from an active PTO request switch.

11. The method of claim 10, wherein at least one of the PTO request switches is a remote PTO request switch.

12. The method of claim 10, wherein at least one of the PTO request switches is a console mounted PTO request switch.

13. The method of claim 10, wherein at least two of the plurality of PTO request switches are active PTO request switches.

14. The method of claim 13, wherein at least one of the active PTO request switches is a primary PTO request switch and at least one of the other of the active PTO switches is a secondary PTO request switch.

15. The method of claim 14, wherein the at least one of the other of the secondary PTO request switches is operable to disengage power take off.

16. The method of claim 10, wherein the PTO request switches communicate via a remote power module to the controller area network.

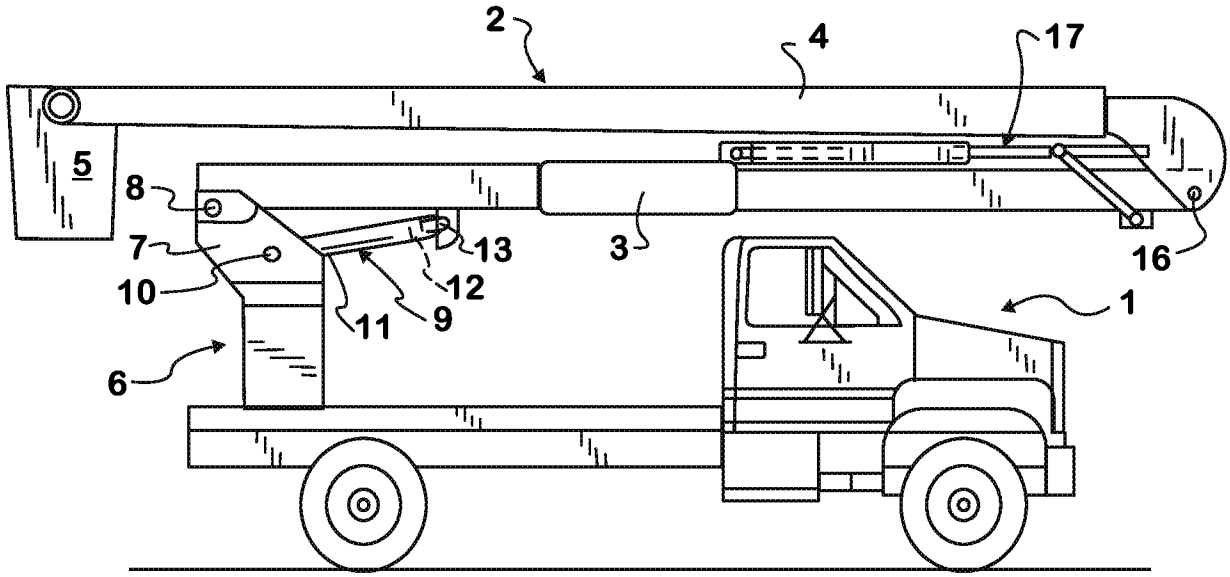


FIG. 1

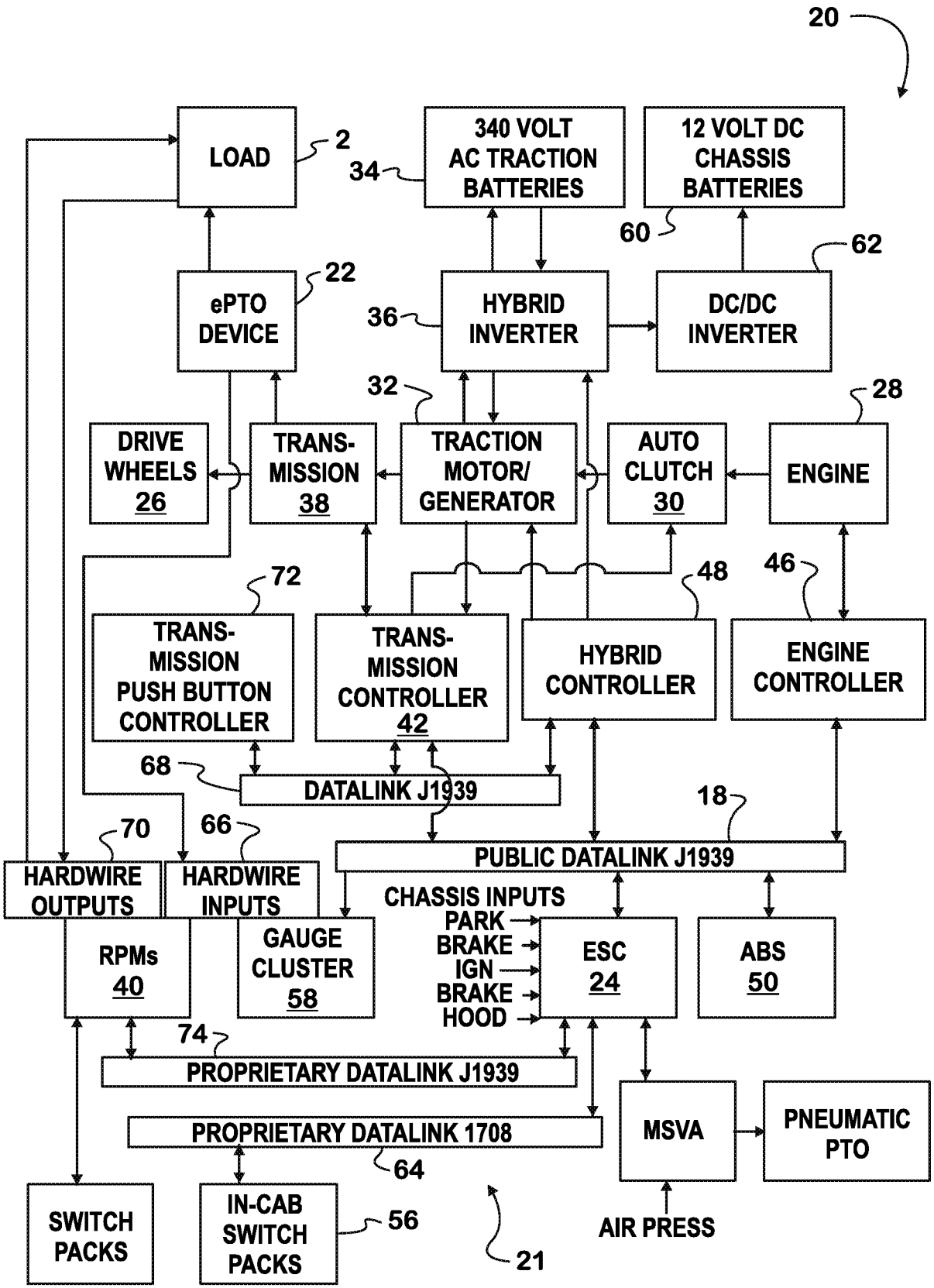

20
LOAD
2
340 VOLT AC TRACTION BATTERIES
34
12 VOLT DC CHASSIS BATTERIES
60
62
ePTO DEVICE
22
HYBRID INVERTER
36
DC/DC INVERTER
32
28
DRIVE WHEELS 26
TRANS-MISSION 38
TRACTION MOTOR/ GENERATOR
AUTO CLUTCH 30
ENGINE
72
48
46
TRANS-MISSION PUSH BUTTON CONTROLLER
TRANS-MISSION CONTROLLER 42
HYBRID CONTROLLER
ENGINE CONTROLLER
68
DATALINK J1939
18
70
66
PUBLIC DATALINK J1939
HARDWIRE OUTPUTS
HARDWIRE INPUTS
CHASSIS INPUTS
PARK
BRAKE
IGN
BRAKE
HOOD
RPMs 40
GAUGE CLUSTER 58
ESC 24
ABS 50
74
PROPRIETARY DATALINK J1939
PROPRIETARY DATALINK 1708
64
MSVA
PNEUMATIC PTO
SWITCH PACKS
IN-CAB SWITCH PACKS
56
21
AIR PRESS

FIG. 2

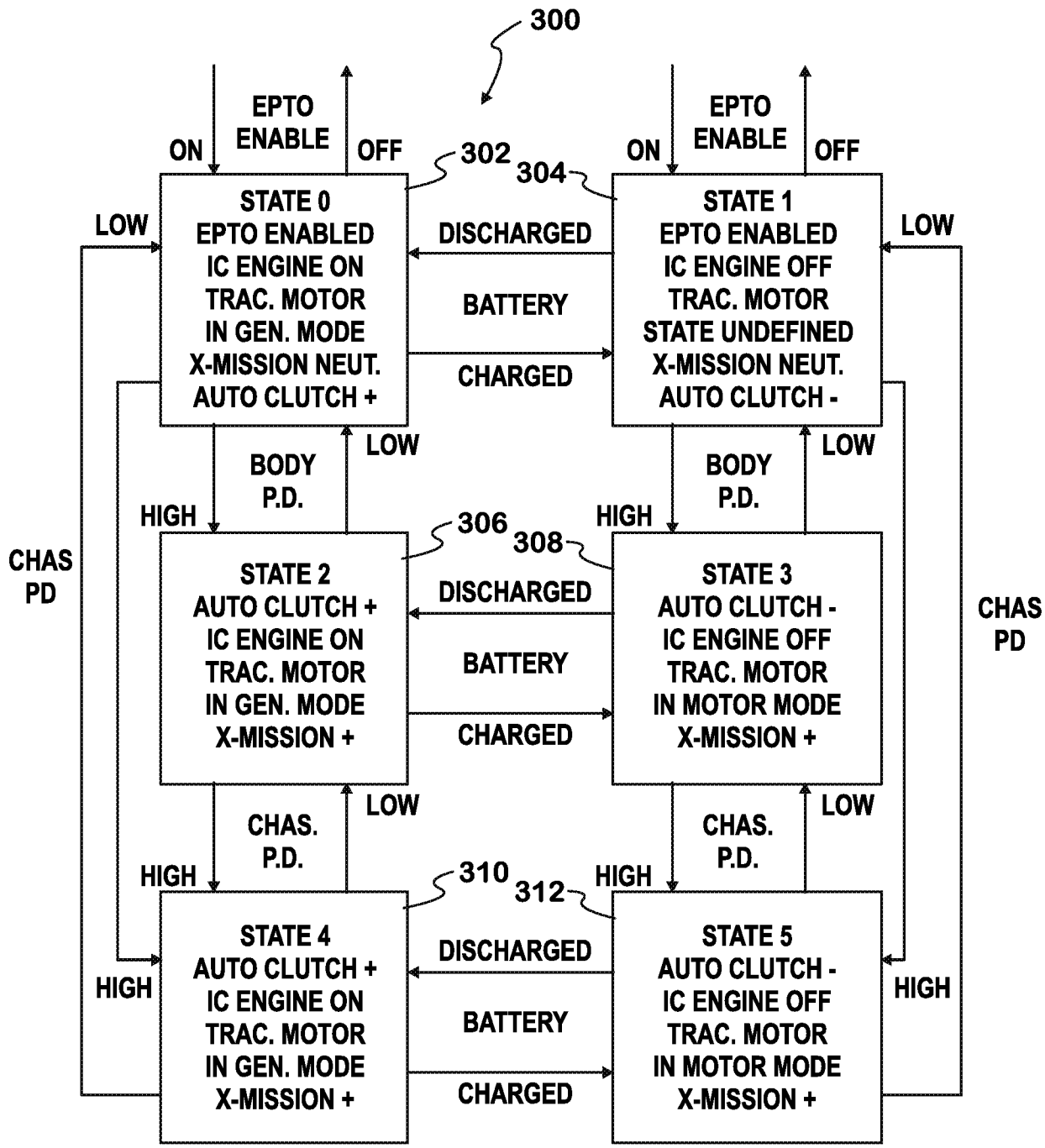

300
EPTO ENABLE
ON
OFF
302
304
STATE 0
EPTO ENABLED
IC ENGINE ON
TRAC. MOTOR
IN GEN. MODE
X-MISSION NEUT.
AUTO CLUTCH +
STATE 1
EPTO ENABLED
IC ENGINE OFF
TRAC. MOTOR
STATE UNDEFINED
X-MISSION NEUT.
AUTO CLUTCH -
LOW
DISCHARGED
BATTERY
CHARGED
BODY P.D.
HIGH
306
308
STATE 2
AUTO CLUTCH +
IC ENGINE ON
TRAC. MOTOR
IN GEN. MODE
X-MISSION +
STATE 3
AUTO CLUTCH -
IC ENGINE OFF
TRAC. MOTOR
IN MOTOR MODE
X-MISSION +
CHAS. P.D.
CHAS PD
310
312
STATE 4
AUTO CLUTCH +
IC ENGINE ON
TRAC. MOTOR
IN GEN. MODE
X-MISSION +
STATE 5
AUTO CLUTCH -
IC ENGINE OFF
TRAC. MOTOR
IN MOTOR MODE
X-MISSION +

FIG. 3

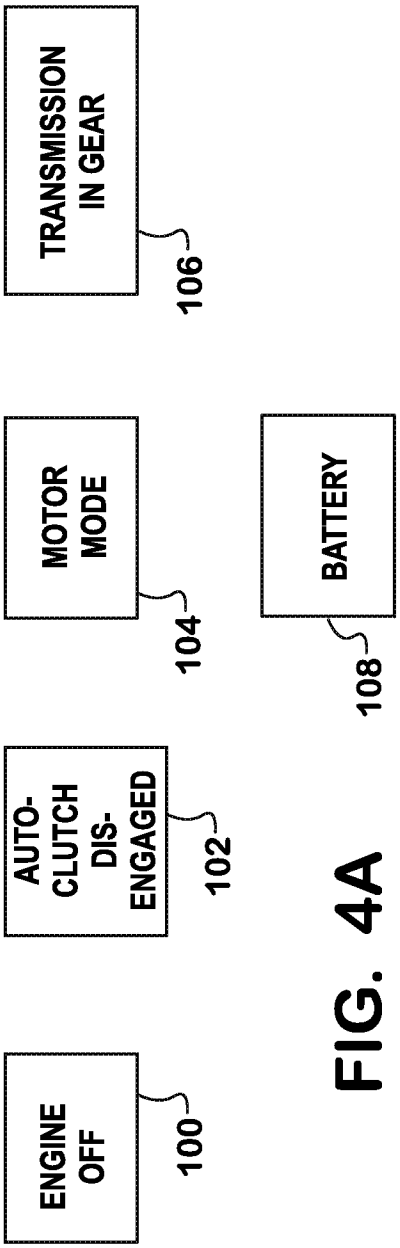

ENGINE OFF
100
AUTO-CLUTCH DIS-ENGAGED
102
MOTOR MODE
104
TRANSMISSION IN GEAR
106
BATTERY
108

FIG. 4A

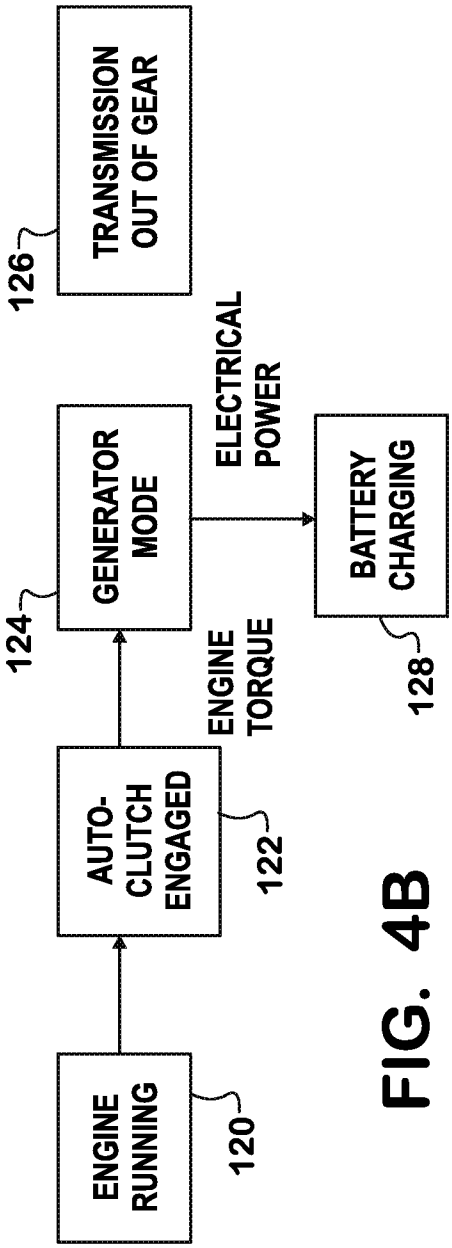

ENGINE RUNNING
120
AUTO-CLUTCH ENGAGED
122
GENERATOR MODE
124
TRANSMISSION OUT OF GEAR
126
BATTERY CHARGING
128
ENGINE TORQUE
ELECTRICAL POWER

FIG. 4B

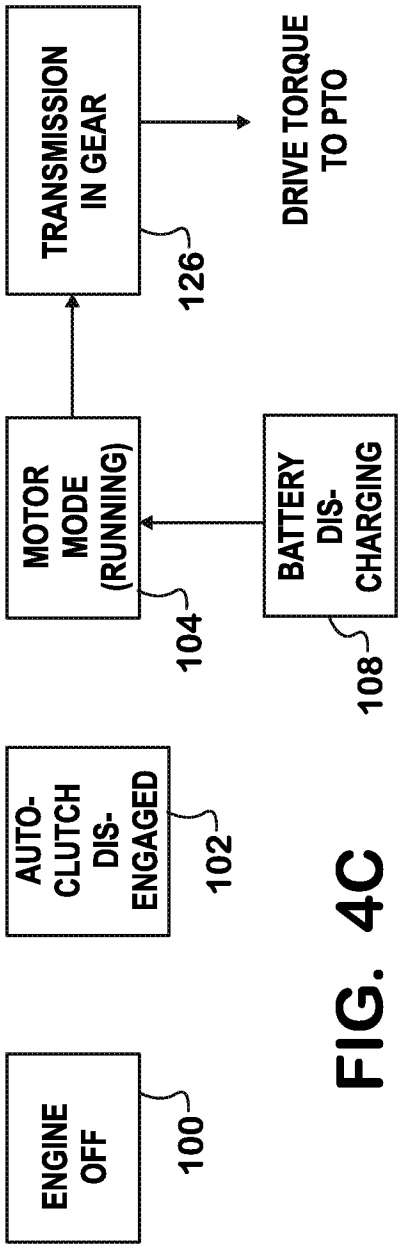

ENGINE OFF
100
AUTO-CLUTCH DIS-ENGAGED
102
MOTOR MODE (RUNNING)
104
BATTERY DIS-CHARGING
108
TRANSMISSION IN GEAR
126
DRIVE TORQUE TO PTO

FIG. 4C

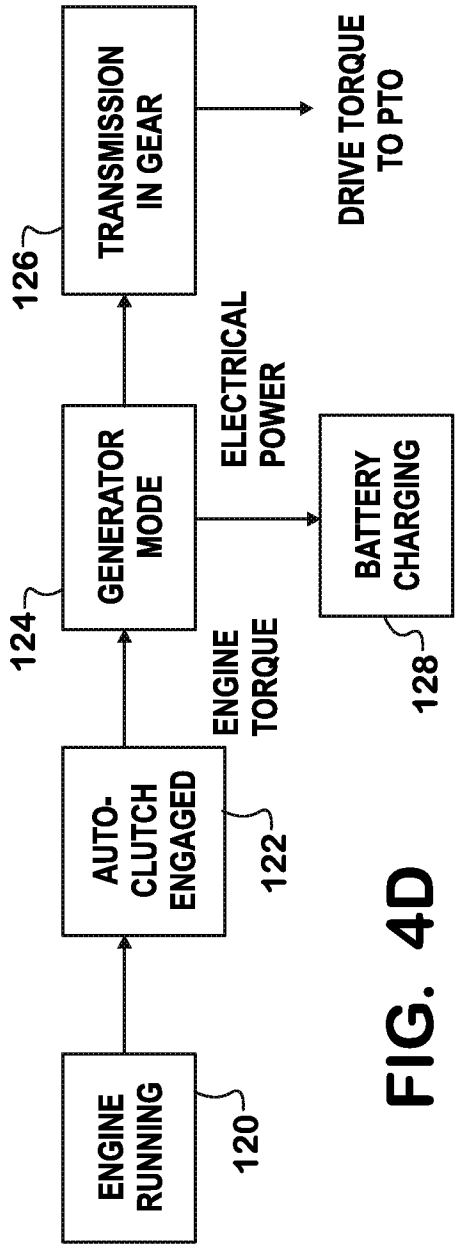

ENGINE RUNNING
120
AUTO-CLUTCH ENGAGED
122
ENGINE TORQUE
GENERATOR MODE
124
ELECTRICAL POWER
BATTERY CHARGING
128
TRANSMISSION IN GEAR
126
DRIVE TORQUE TO PTO

FIG. 4D

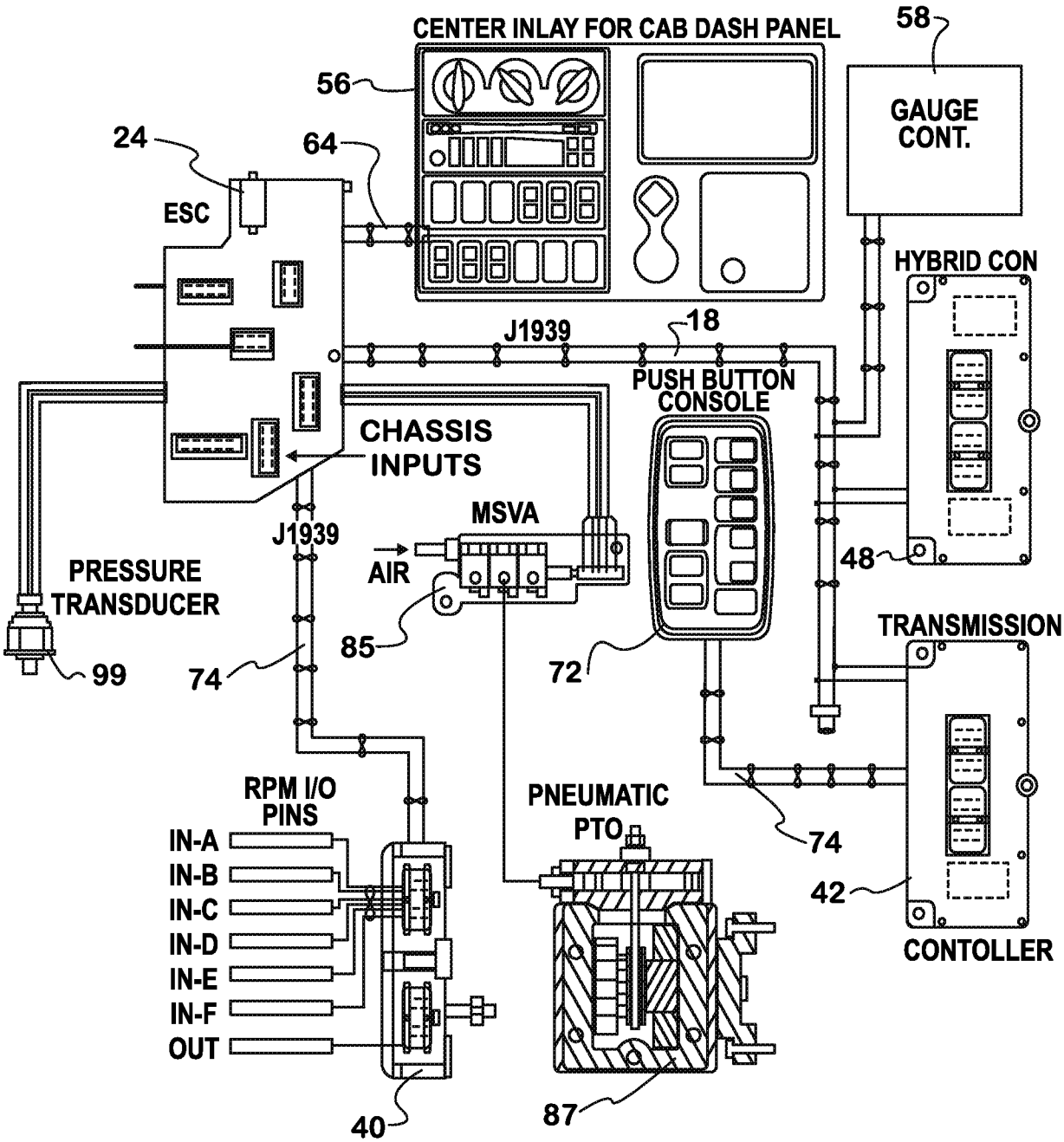

CENTER INLAY FOR CAB DASH PANEL
58
56
GAUGE CONT.
24
64
ESC
HYBRID CON
J1939
18
PUSH BUTTON CONSOLE
CHASSIS INPUTS
MSVA
J1939
AIR
PRESSURE TRANSDUCER
48
TRANSMISSION
85
72
99
74
RPM I/O PINS
PNEUMATIC PTO
IN-A
IN-B
IN-C
IN-D
IN-E
IN-F
OUT
74
42
CONTOLLER
40
87

FIG. 5

FIG. 6

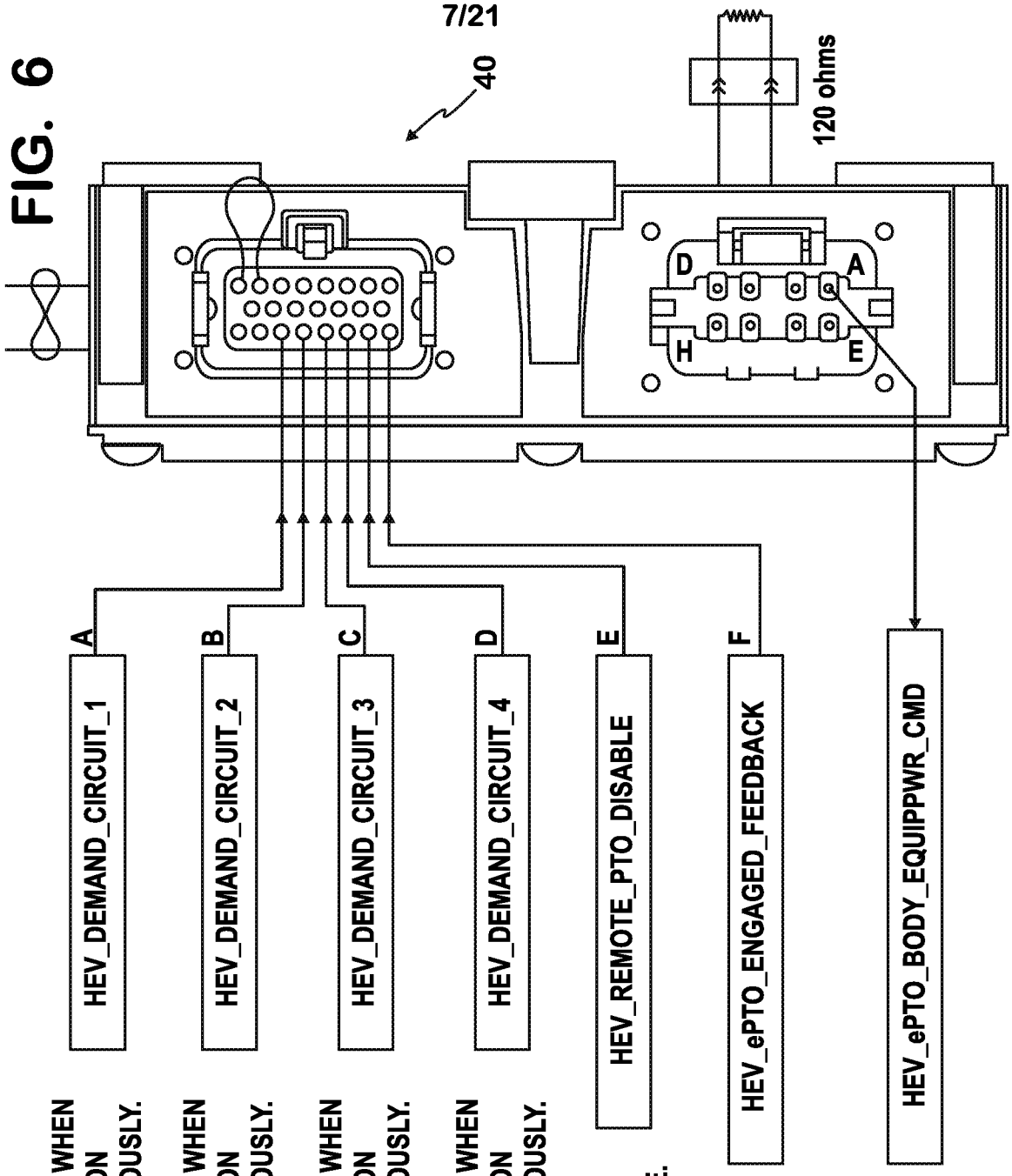
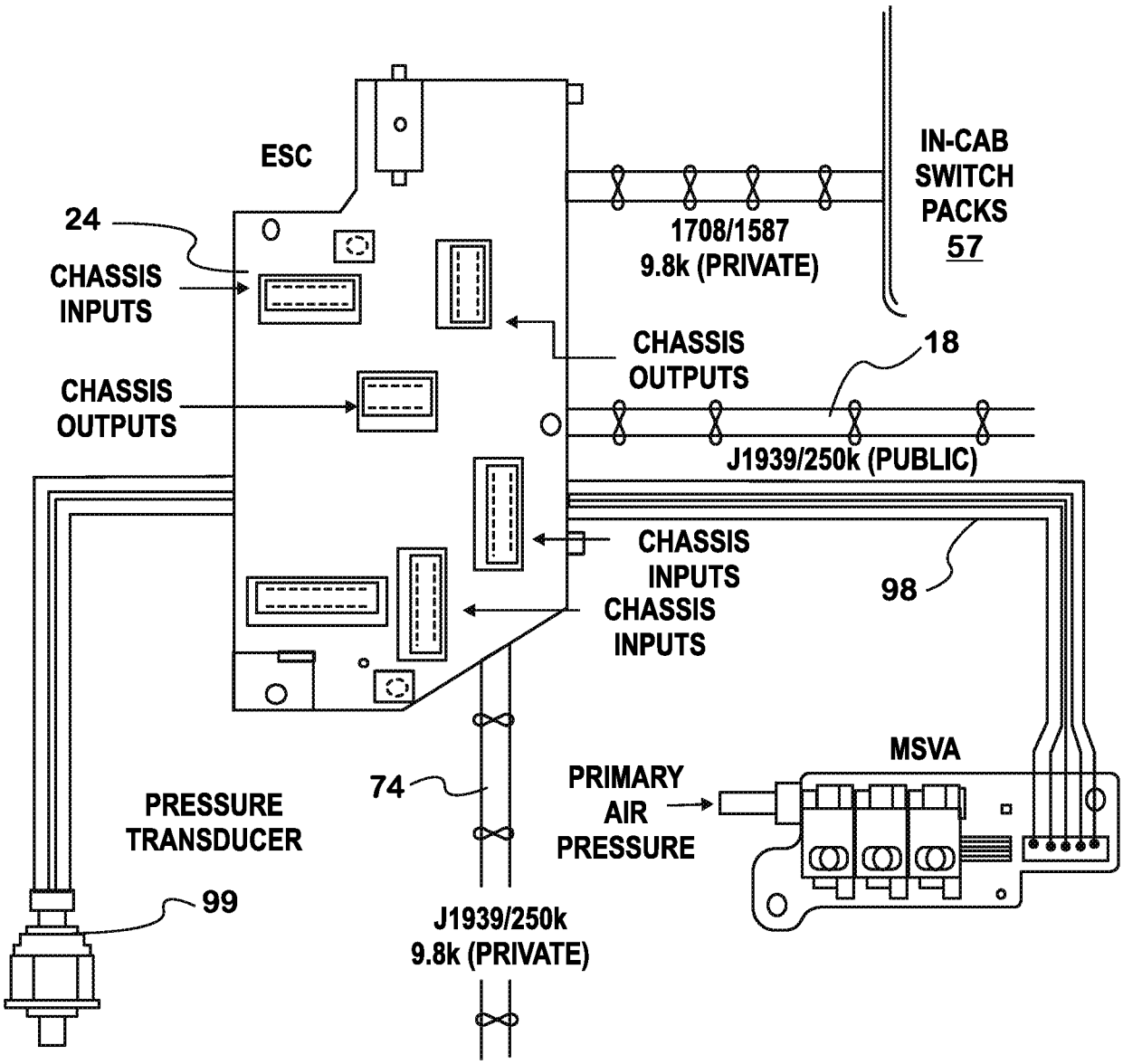

40
120 ohms
D
A
H
E
A
B
C
D
E
F
HEV_DEMAND_CIRCUIT_1
HEV_DEMAND_CIRCUIT_2
HEV_DEMAND_CIRCUIT_3
HEV_DEMAND_CIRCUIT_4
HEV_REMOTE_PTO_DISABLE
HEV_ePTO_ENGAGED_FEEDBACK
HEV_ePTO_BODY_EQUIPPWR_CMD
12VDC OR GND SIGNAL. THIS SIGNAL WHEN ACTIVE WILL REQUEST THE EATON TRACTION MOTOR TO RUN CONTINUOUSLY.
12VDC OR GND SIGNAL. THIS SIGNAL WHEN ACTIVE WILL REQUEST THE EATON TRACTION MOTOR TO RUN CONTINUOUSLY.
12VDC OR GND SIGNAL. THIS SIGNAL WHEN ACTIVE WILL REQUEST THE EATON TRACTION MOTOR TO RUN CONTINUOUSLY.
12VDC OR GND SIGNAL. THIS SIGNAL WHEN ACTIVE WILL REQUEST THE EATON TRACTION MOTOR TO RUN CONTINUOUSLY.
12VDC OR GND SIGNAL. THIS SIGNAL WHEN ACTIVE WILL REQUEST THE PTO TO DISABLE.
GROUND SIGNAL COMING FORM THE PTO MOUNTED PRESSURE OR BALL DETENT FEEDBACK SWITCH.
12VDC/20AMPS
INTERLOCKED TO:
*VEHICLE SPEED < 3MPH
*NEUTRAL GEAR
*PARK BRAKE SET

FIG. 7


ESC
24
CHASSIS INPUTS
CHASSIS OUTPUTS
IN-CAB SWITCH PACKS
57
1708/1587
9.8k (PRIVATE)
CHASSIS OUTPUTS
18
J1939/250k (PUBLIC)
CHASSIS INPUTS
CHASSIS INPUTS
98
MSVA
PRIMARY AIR PRESSURE
74
PRESSURE TRANSDUCER
99
J1939/250k
9.8k (PRIVATE)

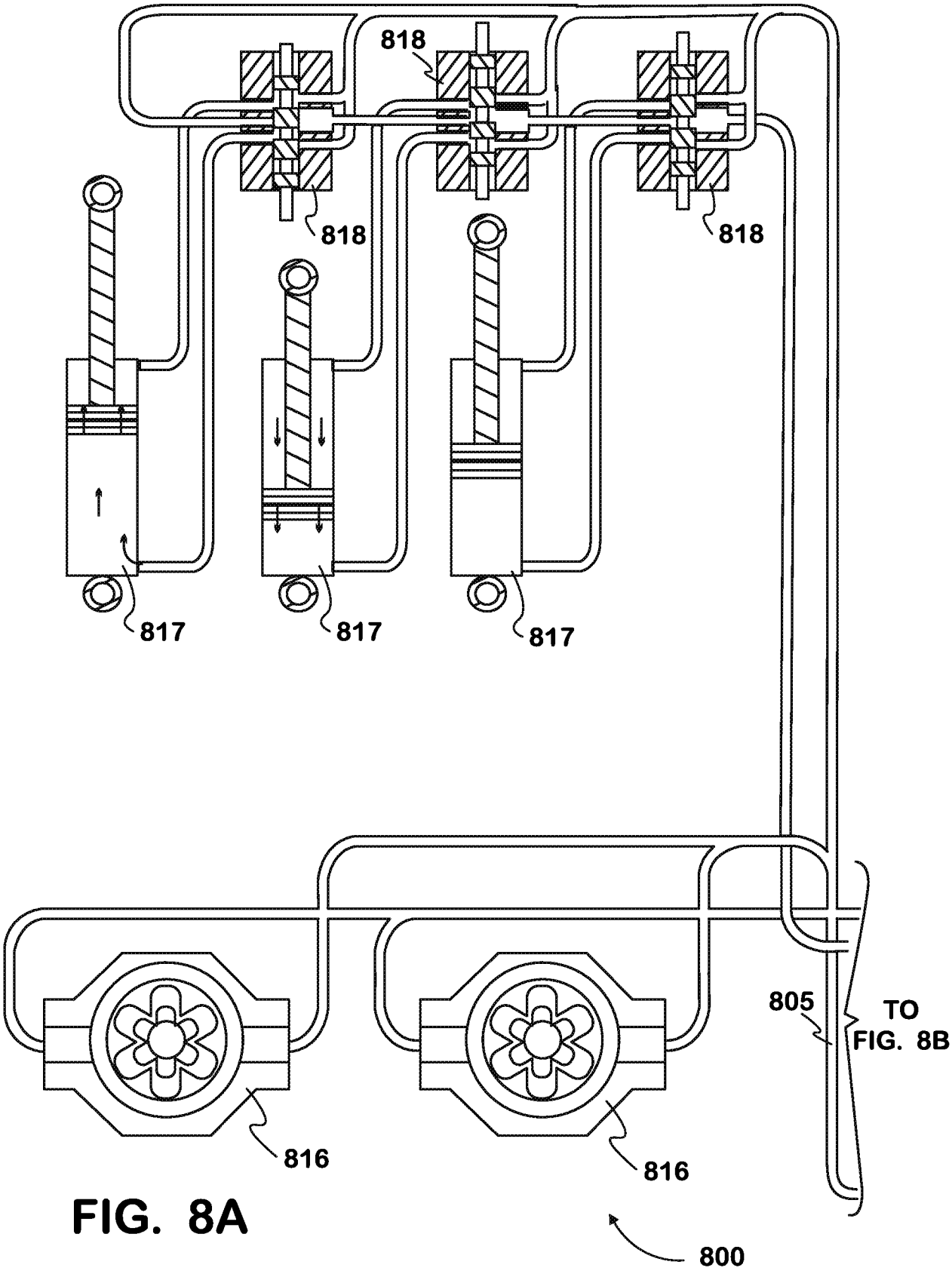


FIG. 8A

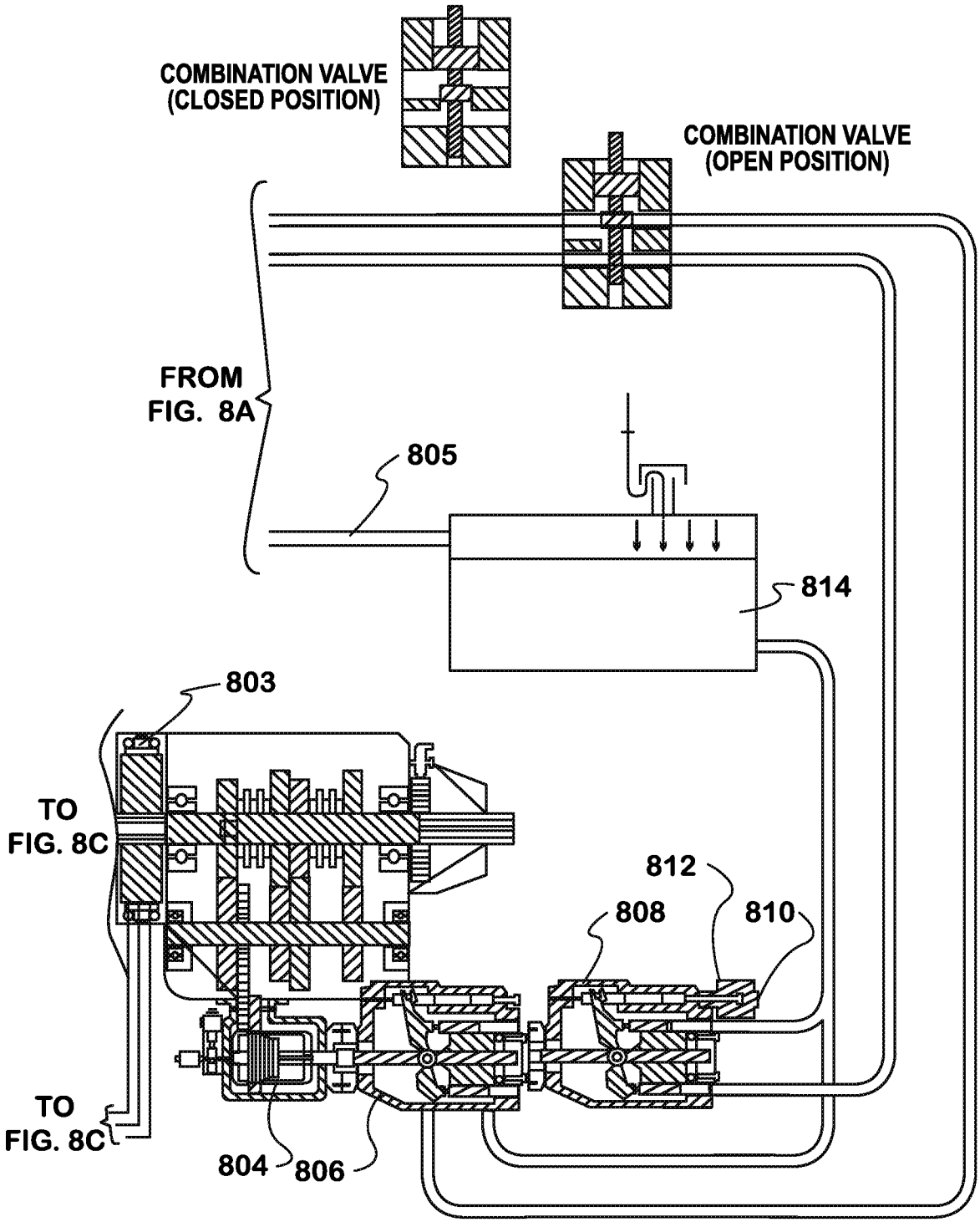

COMBINATION VALVE
(CLOSED POSITION)
COMBINATION VALVE
(OPEN POSITION)
FROM
FIG. 8A
805
814
803
TO
FIG. 8C
812
808
810
TO
FIG. 8C
804
806

FIG. 8B

800

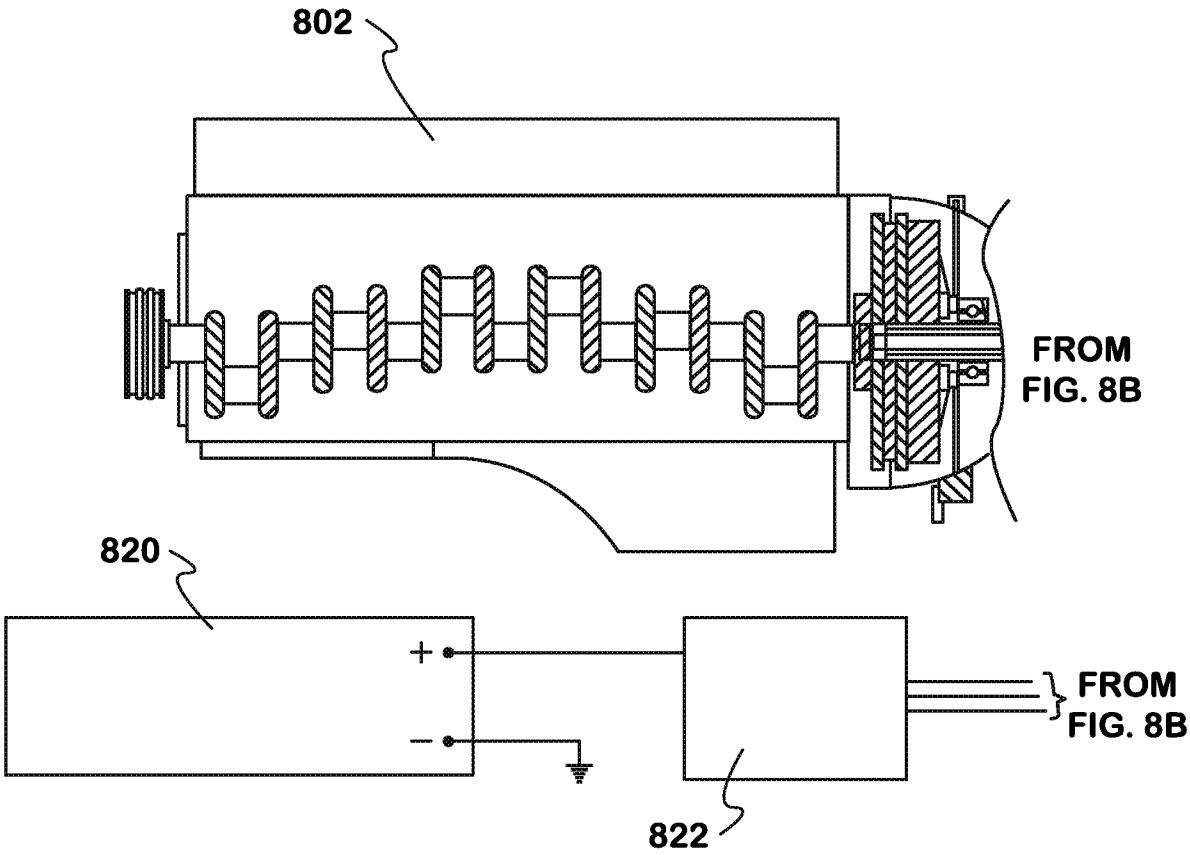


FIG. 8C

800

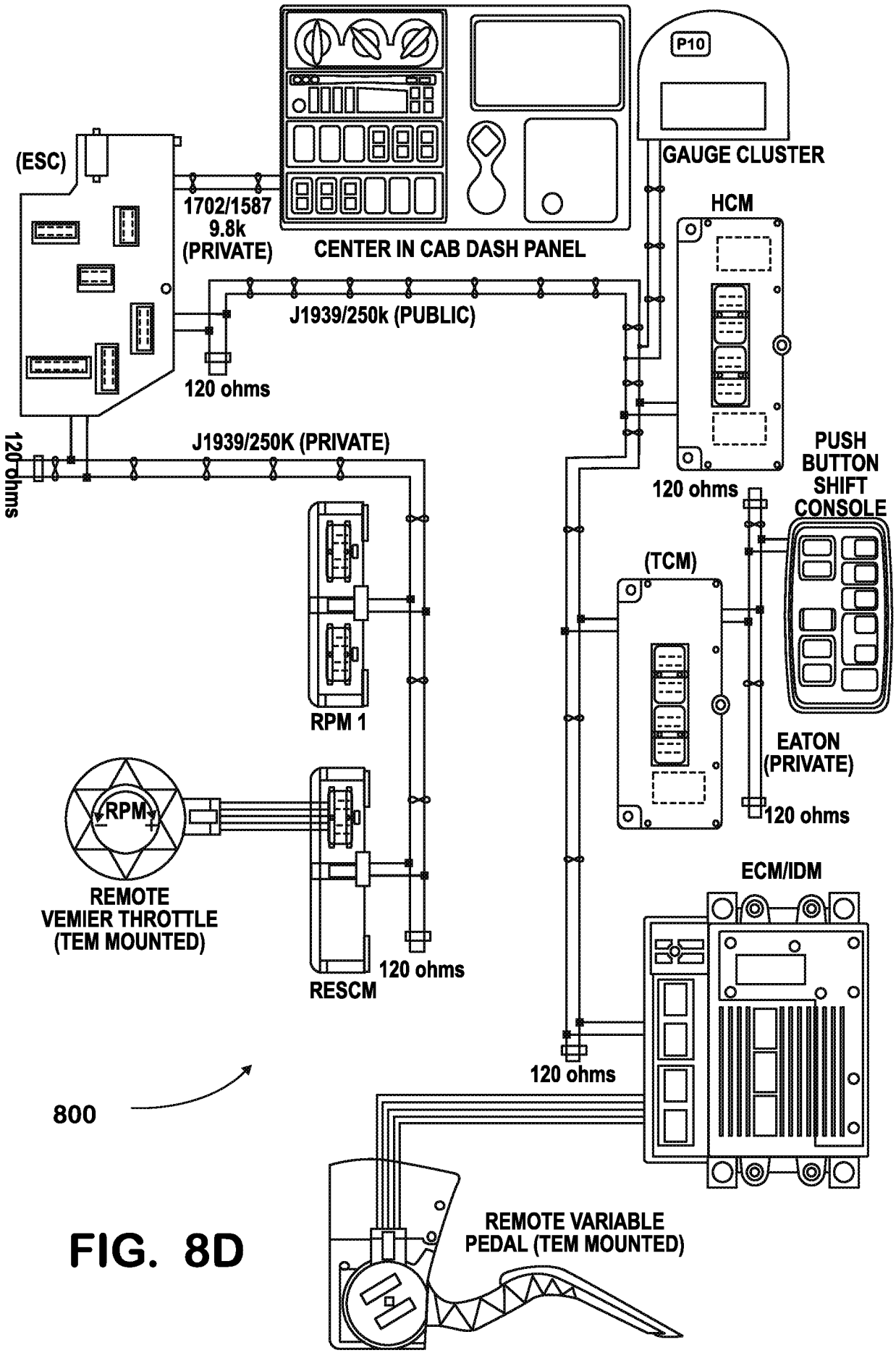

P10
GAUGE CLUSTER
(ESC)
1702/1587
9.8k
(PRIVATE)
CENTER IN CAB DASH PANEL
HCM
J1939/250k (PUBLIC)
120 ohms
120 ohms
J1939/250K (PRIVATE)
120 ohms
PUSH
BUTTON
SHIFT
CONSOLE
(TCM)
RPM 1
EATON
(PRIVATE)
120 ohms
RPM
REMOTE
VEMIER THROTTLE
(TEM MOUNTED)
120 ohms
RESCM
ECM/IDM
120 ohms
800
REMOTE VARIABLE
PEDAL (TEM MOUNTED)

FIG. 8D

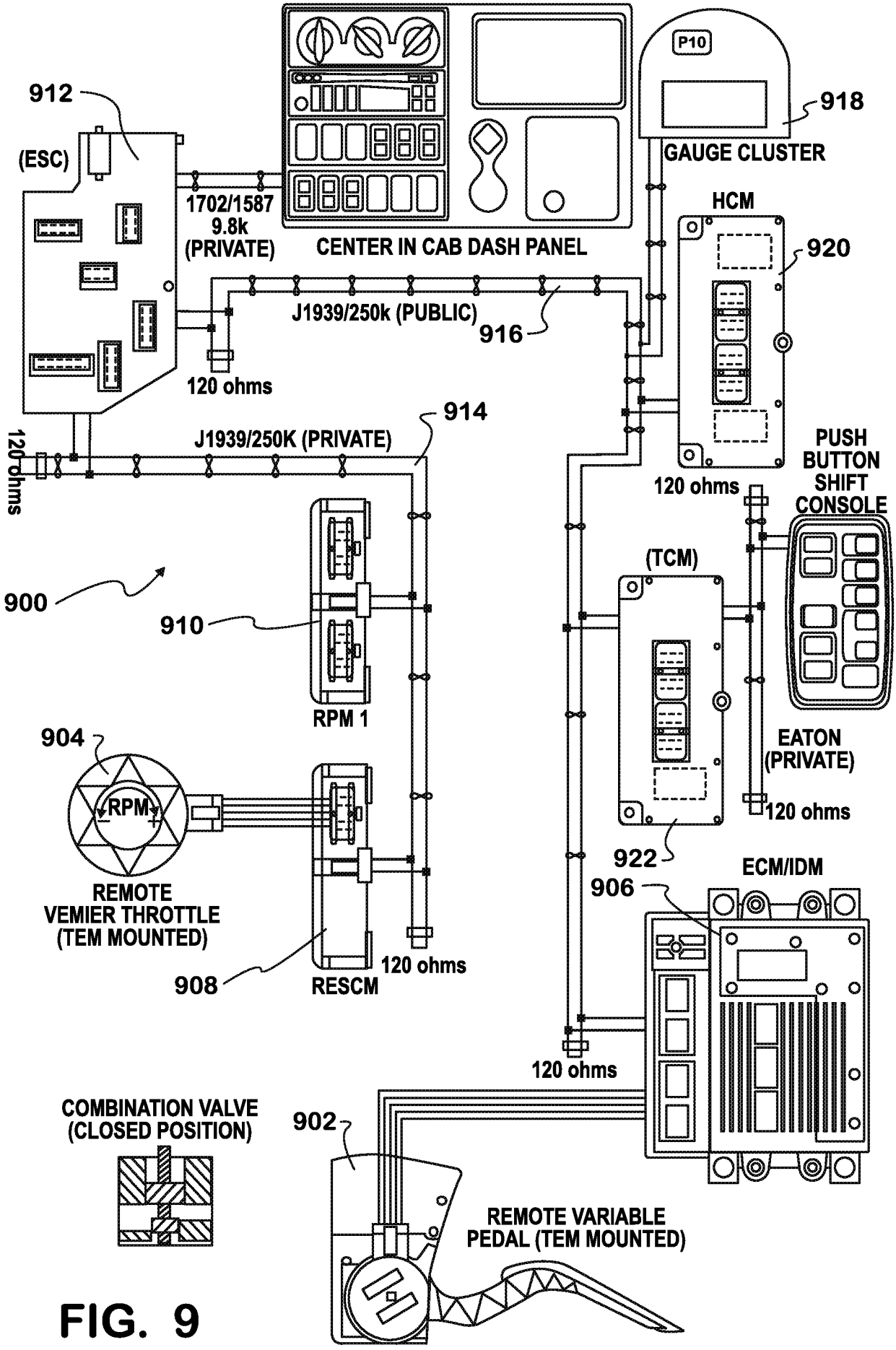

912
(ESC)
1702/1587
9.8k
(PRIVATE)
CENTER IN CAB DASH PANEL
P10
918
GAUGE CLUSTER
HCM
920
J1939/250k (PUBLIC)
916
120 ohms
914
J1939/250K (PRIVATE)
120 ohms
120 ohms
PUSH
BUTTON
SHIFT
CONSOLE
900
910
(TCM)
RPM 1
904
RPM
EATON
(PRIVATE)
120 ohms
922
ECM/IDM
906
REMOTE
VEMIER THROTTLE
(TEM MOUNTED)
908
RESCM
120 ohms
120 ohms
COMBINATION VALVE
(CLOSED POSITION)
902
REMOTE VARIABLE
PEDAL (TEM MOUNTED)

FIG. 9

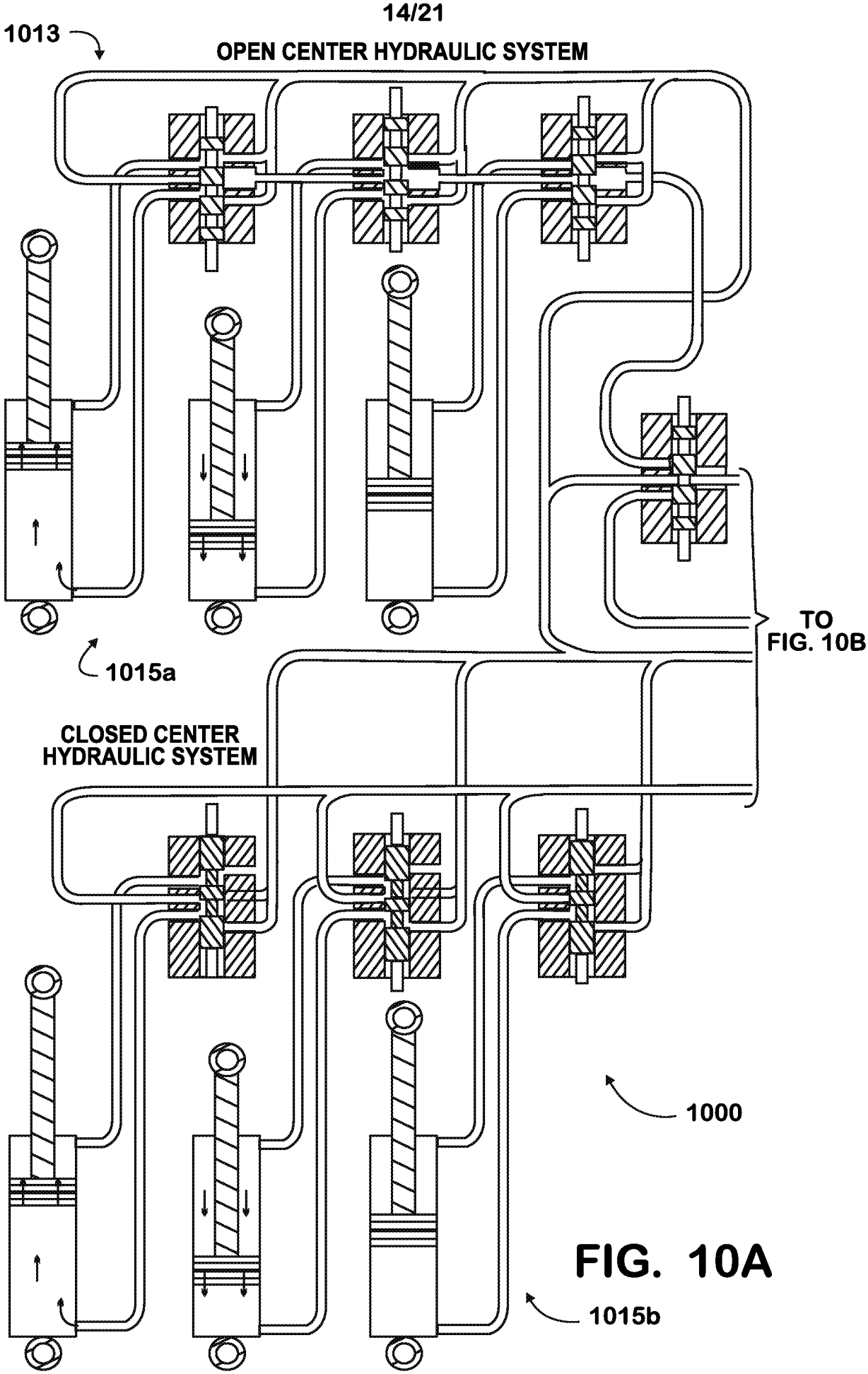

1013
OPEN CENTER HYDRAULIC SYSTEM
TO FIG. 10B
1015a
CLOSED CENTER HYDRAULIC SYSTEM
1000
1015b

FIG. 10A

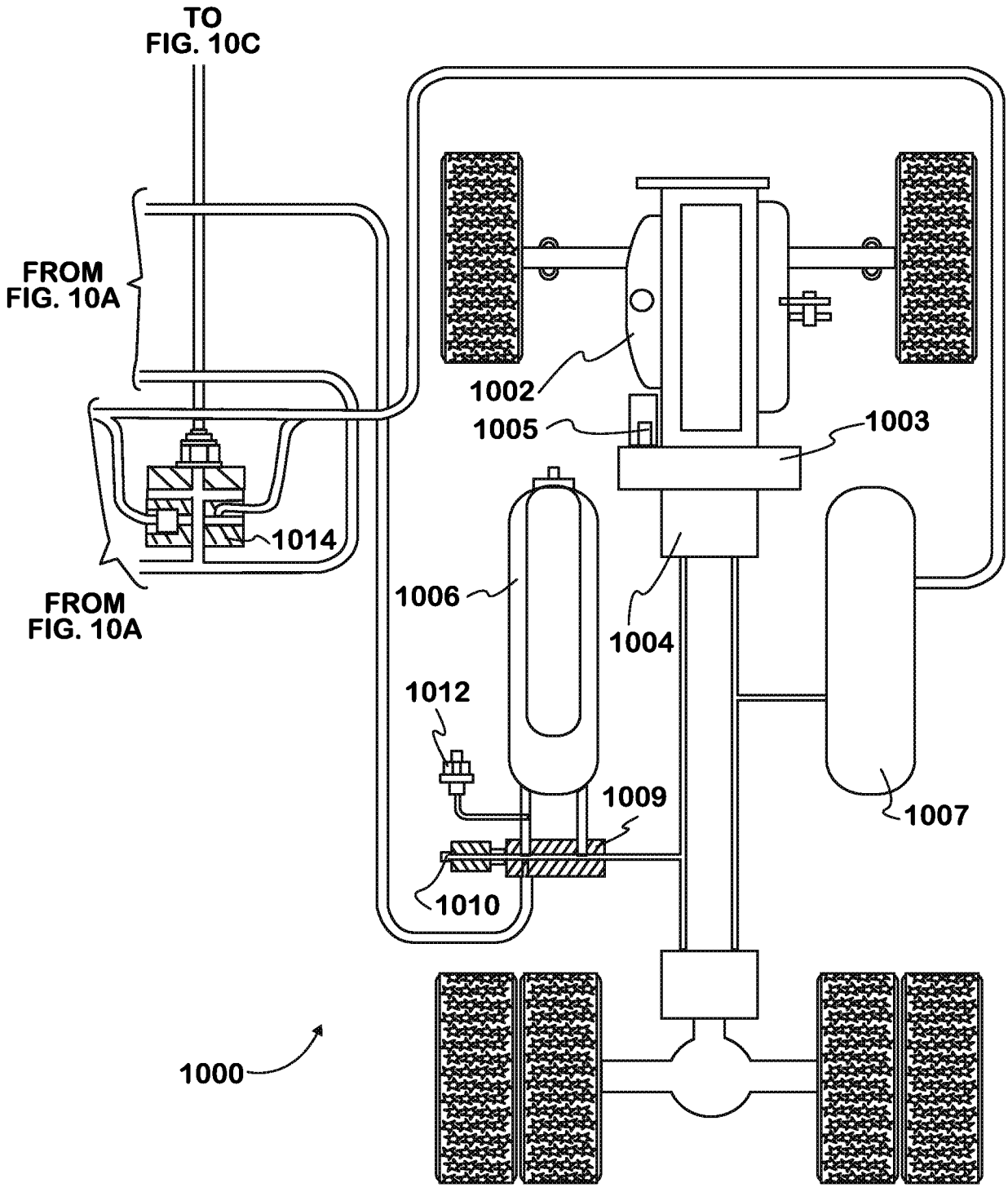

TO
FIG. 10C
FROM
FIG. 10A
FROM
FIG. 10A
1002
1005
1003
1014
1006
1004
1012
1009
1007
1010
1000

FIG. 10B

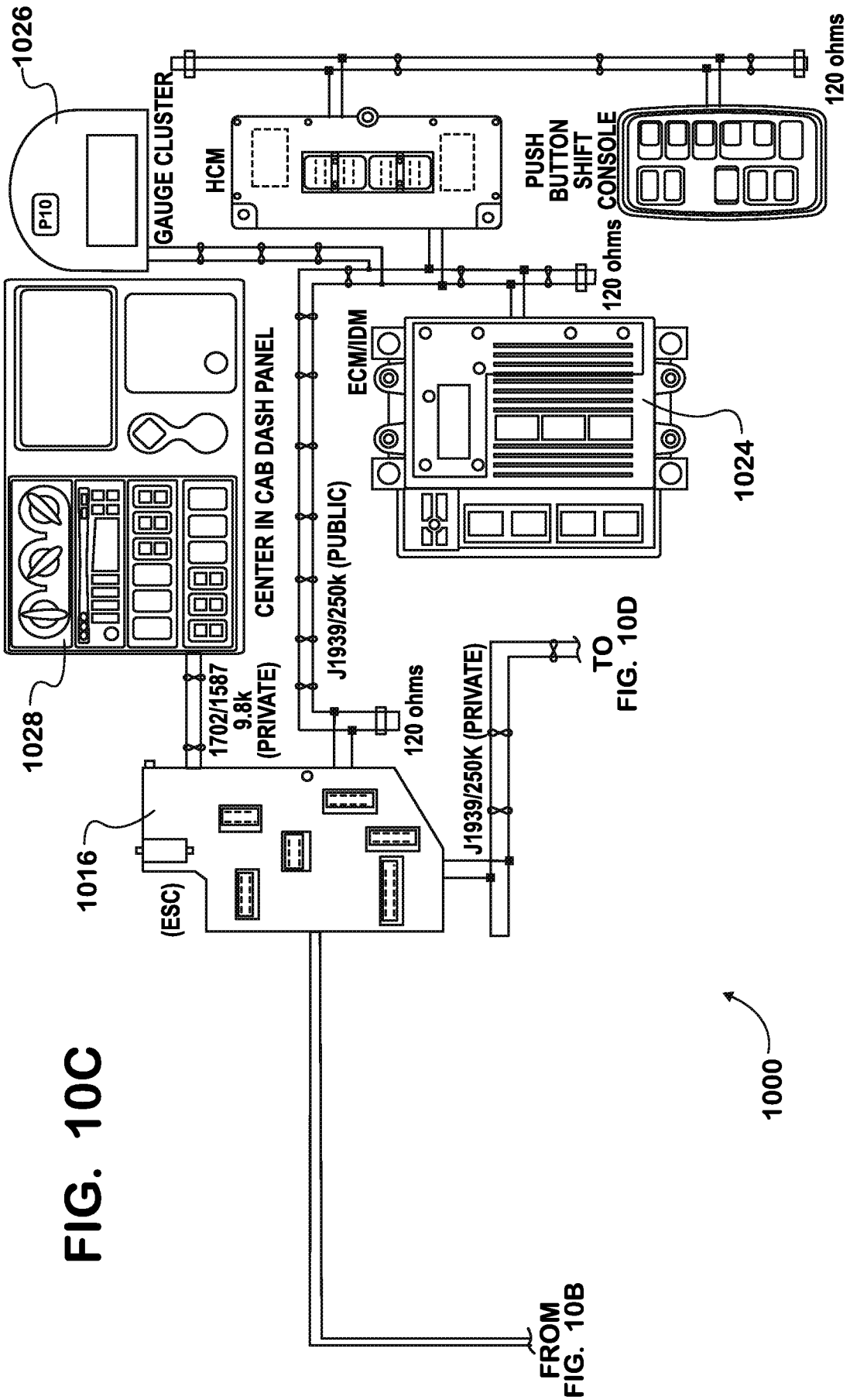

1026
GAUGE CLUSTER
P10
HCM
PUSH BUTTON SHIFT CONSOLE
120 ohms
120 ohms
ECM/IDM
1024
CENTER IN CAB DASH PANEL
J1939/250k (PUBLIC)
1028
1702/1587
9.8k
(PRIVATE)
120 ohms
J1939/250K (PRIVATE)
TO FIG. 10D
1016
(ESC)
1000
FROM FIG. 10B

FIG. 10C

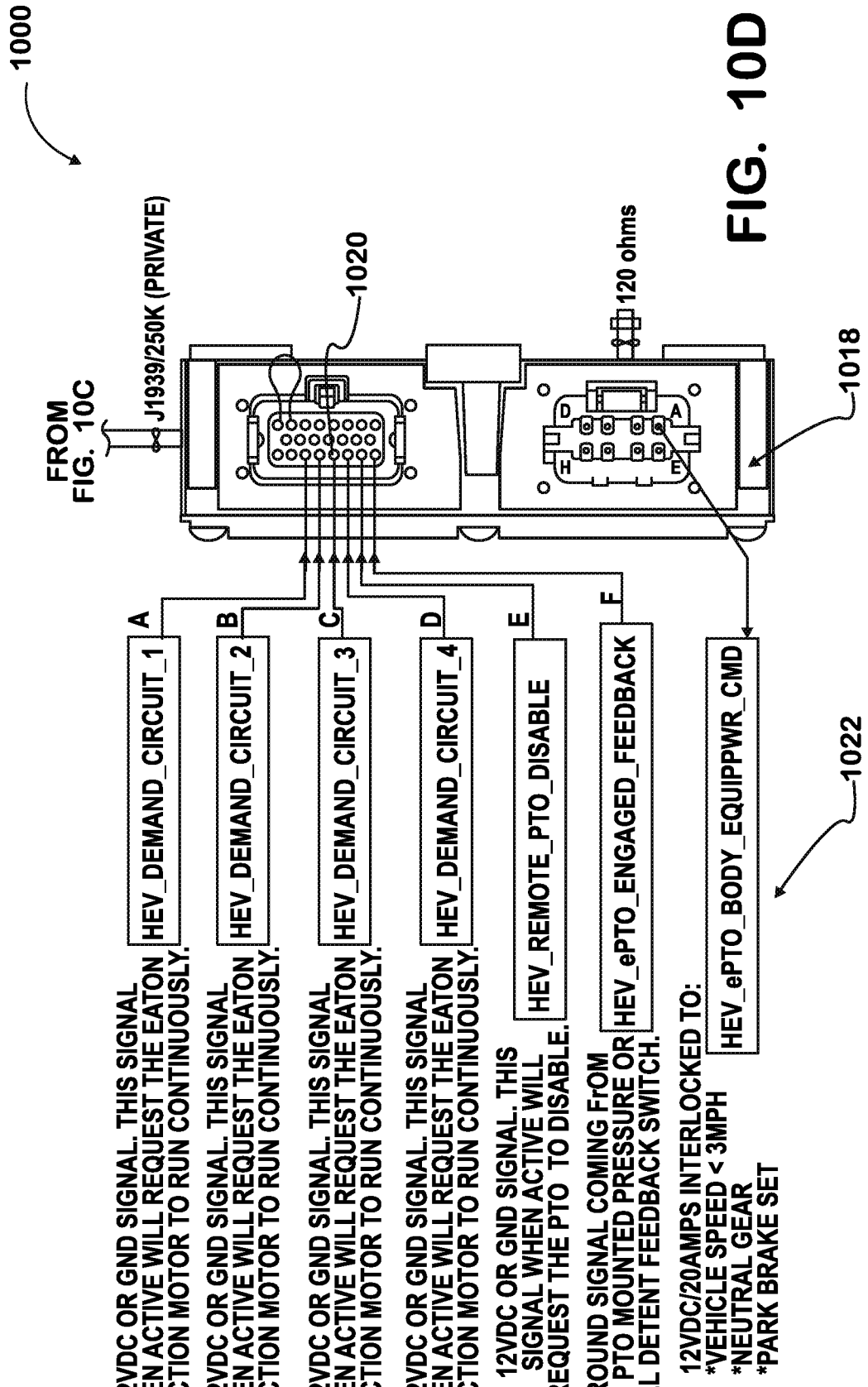

1000
FROM FIG. 10C
J1939/250K (PRIVATE)
1020
120 ohms
1018
1022
A
B
C
D
E
F
HEV_DEMAND_CIRCUIT_1
HEV_DEMAND_CIRCUIT_2
HEV_DEMAND_CIRCUIT_3
HEV_DEMAND_CIRCUIT_4
HEV_REMOTE_PTO_DISABLE
HEV_ePTO_ENGAGED_FEEDBACK
HEV_ePTO_BODY_EQUIPPWR_CMD
12VDC OR GND SIGNAL. THIS SIGNAL WHEN ACTIVE WILL REQUEST THE EATON TRACTION MOTOR TO RUN CONTINUOUSLY.
12VDC OR GND SIGNAL. THIS SIGNAL WHEN ACTIVE WILL REQUEST THE EATON TRACTION MOTOR TO RUN CONTINUOUSLY.
12VDC OR GND SIGNAL. THIS SIGNAL WHEN ACTIVE WILL REQUEST THE EATON TRACTION MOTOR TO RUN CONTINUOUSLY.
12VDC OR GND SIGNAL. THIS SIGNAL WHEN ACTIVE WILL REQUEST THE EATON TRACTION MOTOR TO RUN CONTINUOUSLY.
12VDC OR GND SIGNAL. THIS SIGNAL WHEN ACTIVE WILL REQUEST THE PTO TO DISABLE.
GROUND SIGNAL COMING FrOM THE PTO MOUNTED PRESSURE OR BALL DETENT FEEDBACK SWITCH.
12VDC/20AMPS INTERLOCKED TO:
*VEHICLE SPEED < 3MPH
*NEUTRAL GEAR
*PARK BRAKE SET
D
A
H
E

FIG. 10D

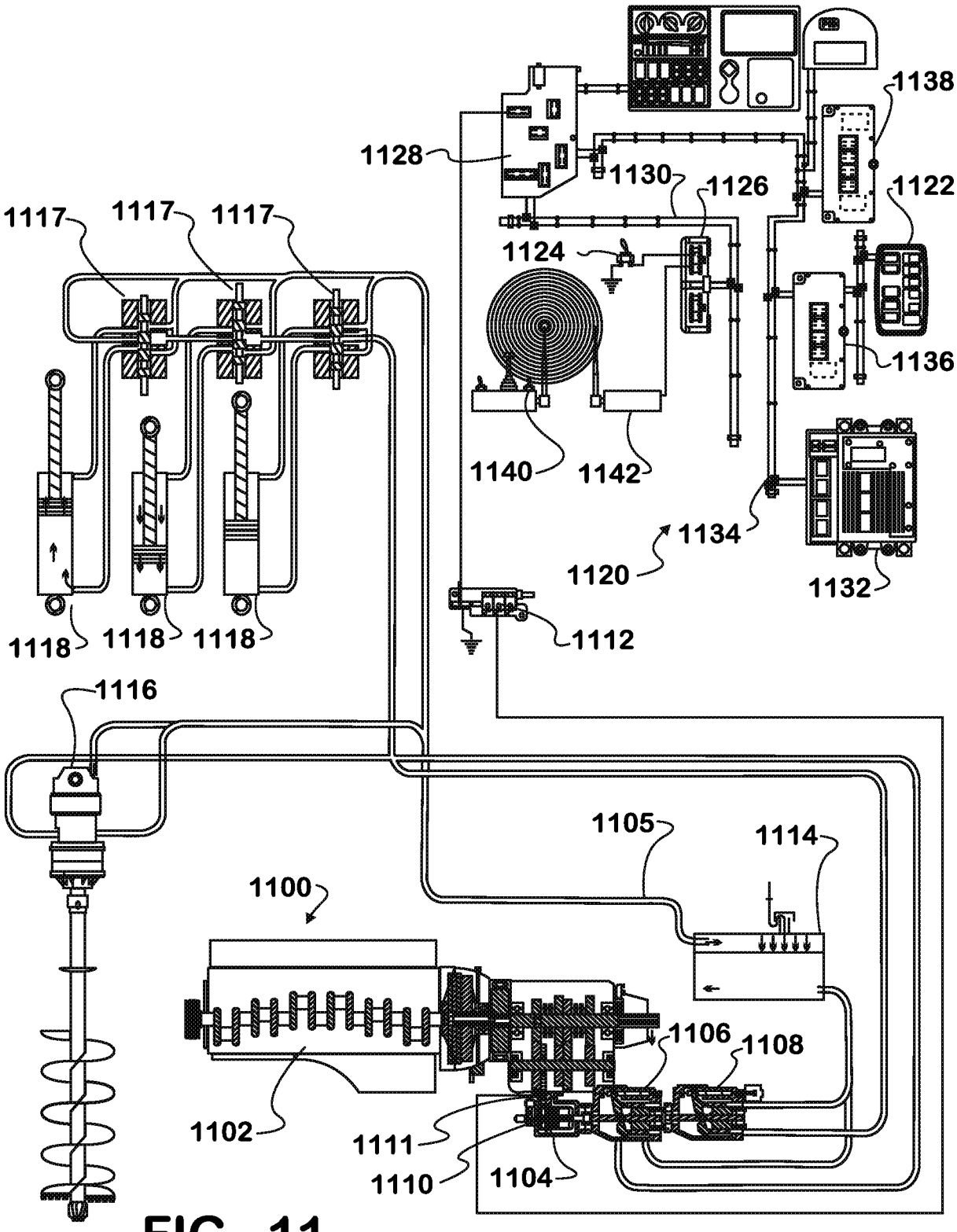

1138
1128
1130
1126
1122
1117
1117
1117
1124
1136
1140
1142
1134
1120
1132
1118
1118
1118
1112
1116
1105
1114
1100
1106
1108
1102
1111
1110
1104

FIG. 11

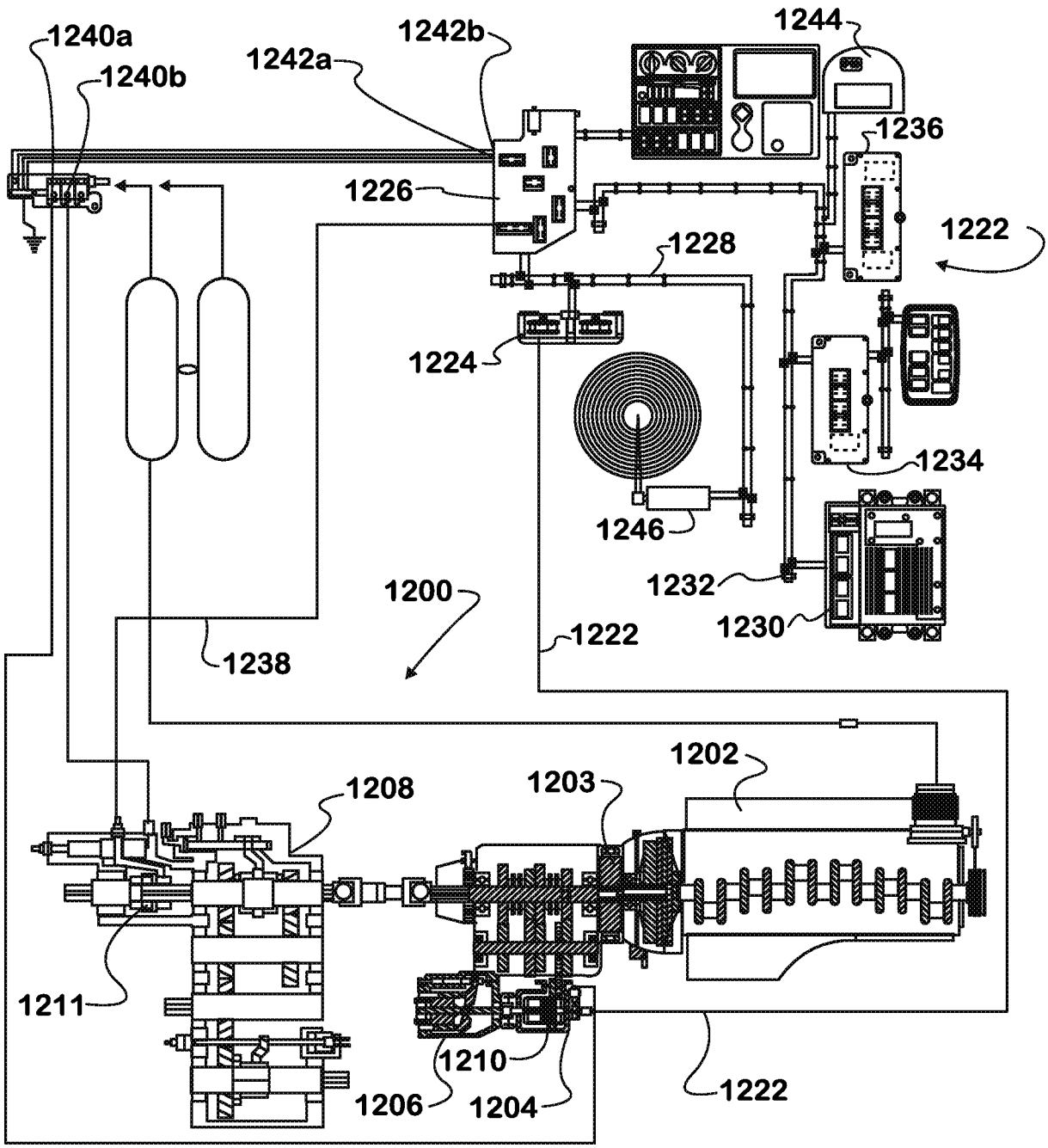

1240a
1240b
1242a
1242b
1244
1236
1226
1222
1228
1224
1234
1246
1232
1230
1200
1238
1222
1202
1208
1203
1211
1210
1206
1204
1222

FIG. 12

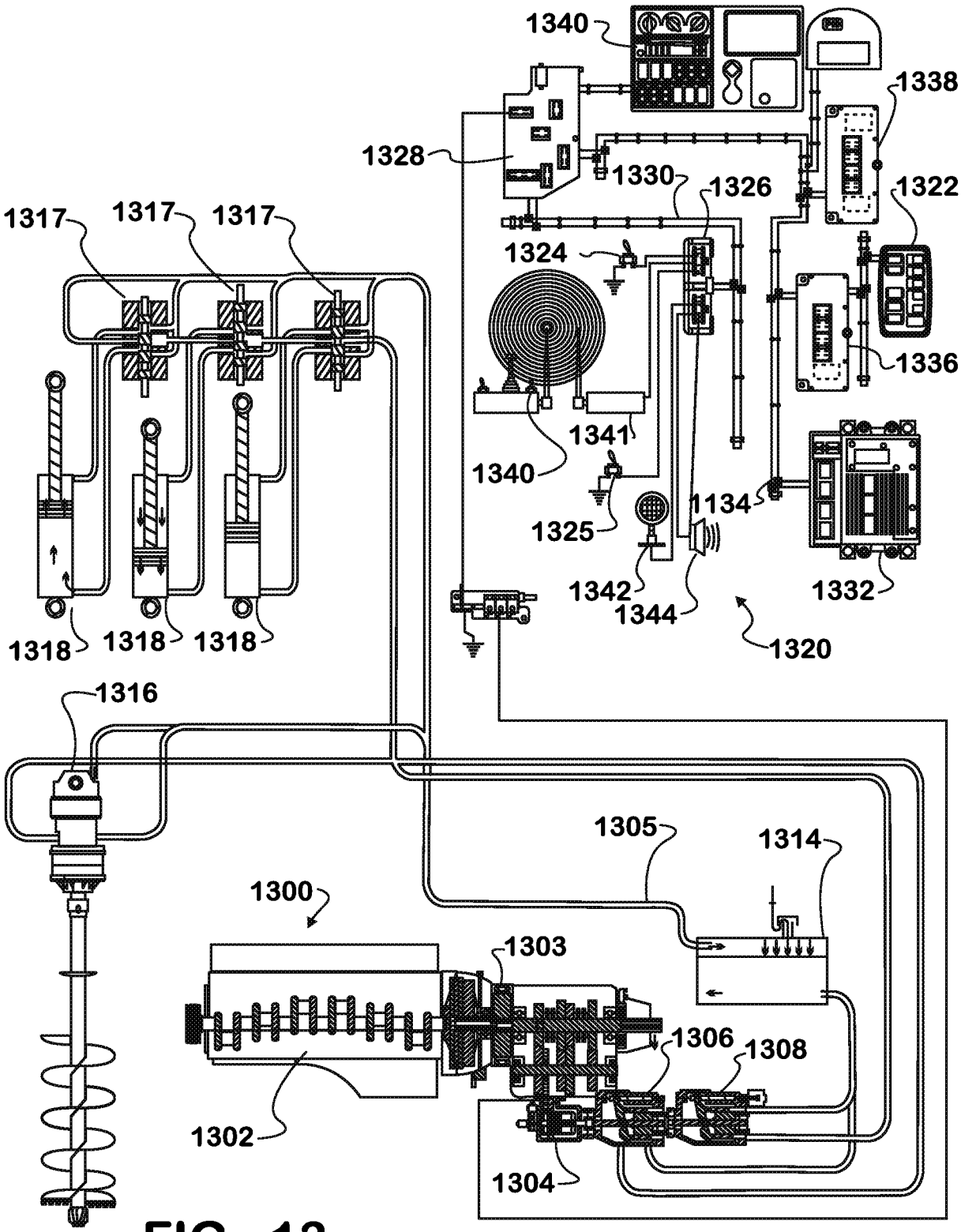

1340
1338
1328
1330
1326
1322
1317
1317
1317
1324
1336
1341
1340
1134
1325
1342
1344
1332
1320
1318
1318
1318
1316
1305
1314
1300
1303
1306
1308
1302
1304

FIG. 13

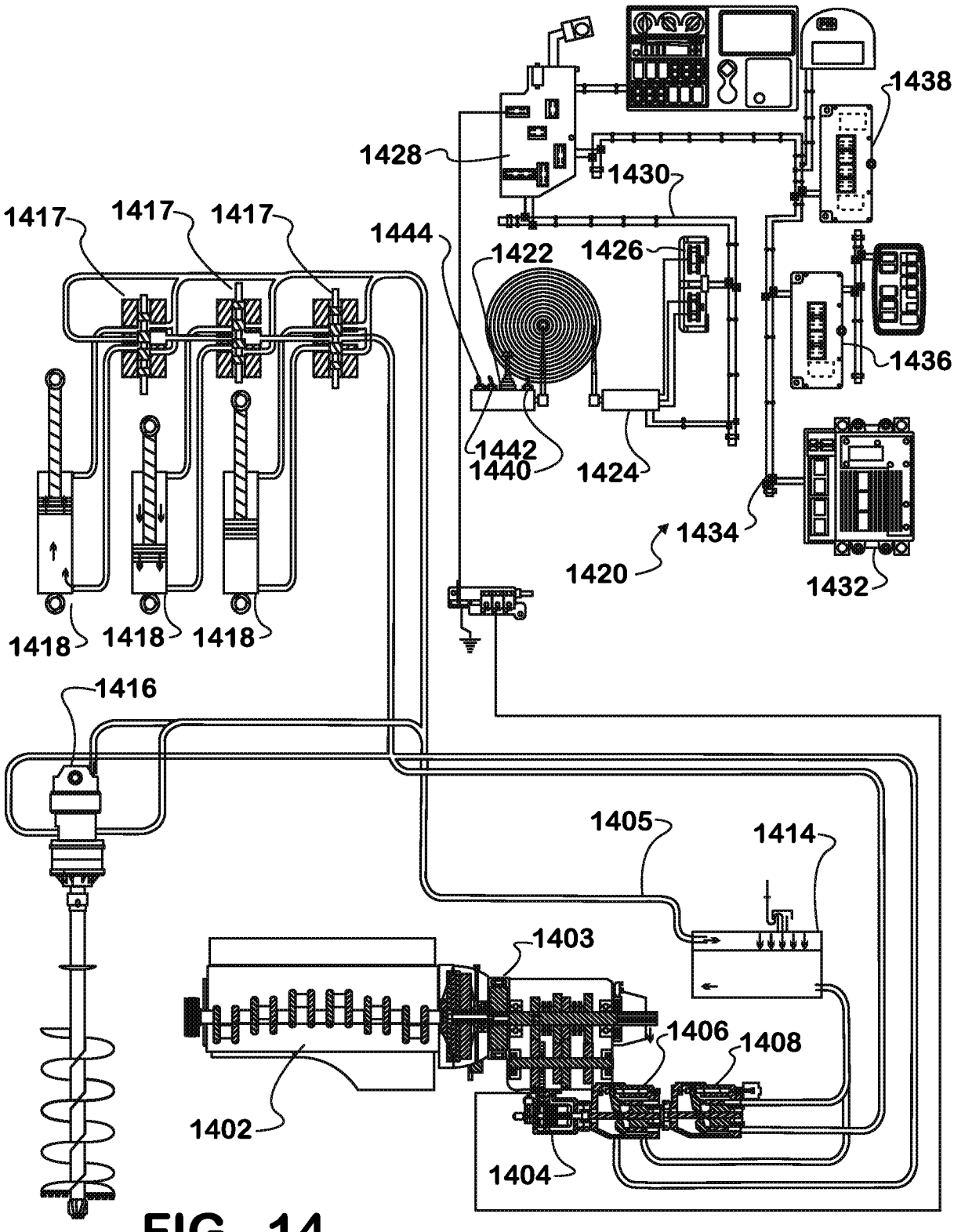

1438
1428
1430
1417
1417
1417
1444
1422
1426
1436
1442
1440
1424
1434
1420
1432
1418
1418
1418
1416
1405
1414
1403
1406
1408
1402
1404

FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/039778

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B60W 20/00 (2010.01)
USPC - 180/65.275
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B60K 25/08; B60W 20/00 (2010.01)
USPC - 180/53.6, 65.265, 65.275

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7,281,595 B2 (BISSONTZ) 16 October 2007 (16.10.2007) entire document	1-3, 8
---		---
Y		4-7, 9-20
Y	US 6,272,402 B1 (KELWASKI) 07 August 2001 (07.08.2001) entire document	4, 9, 15, 20
Y	US 2009/0044993 A1 (BISSONTZ) 19 February 2009 (19.02.2009) entire document	5-7, 10-20
A	US 2004/0084229 A1 (STANCU et al) 06 May 2004 (06.05.2004) entire document	1-20
A	US 7,252,165 B1 (GRUENWALD et al) 07 August 2007 (07.08.2007) entire document	1-20
A	US 2007/0012492 A1 (DENG et al) 18 January 2007 (18.01.2007) entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 August 2010	01 SEP 2010

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)